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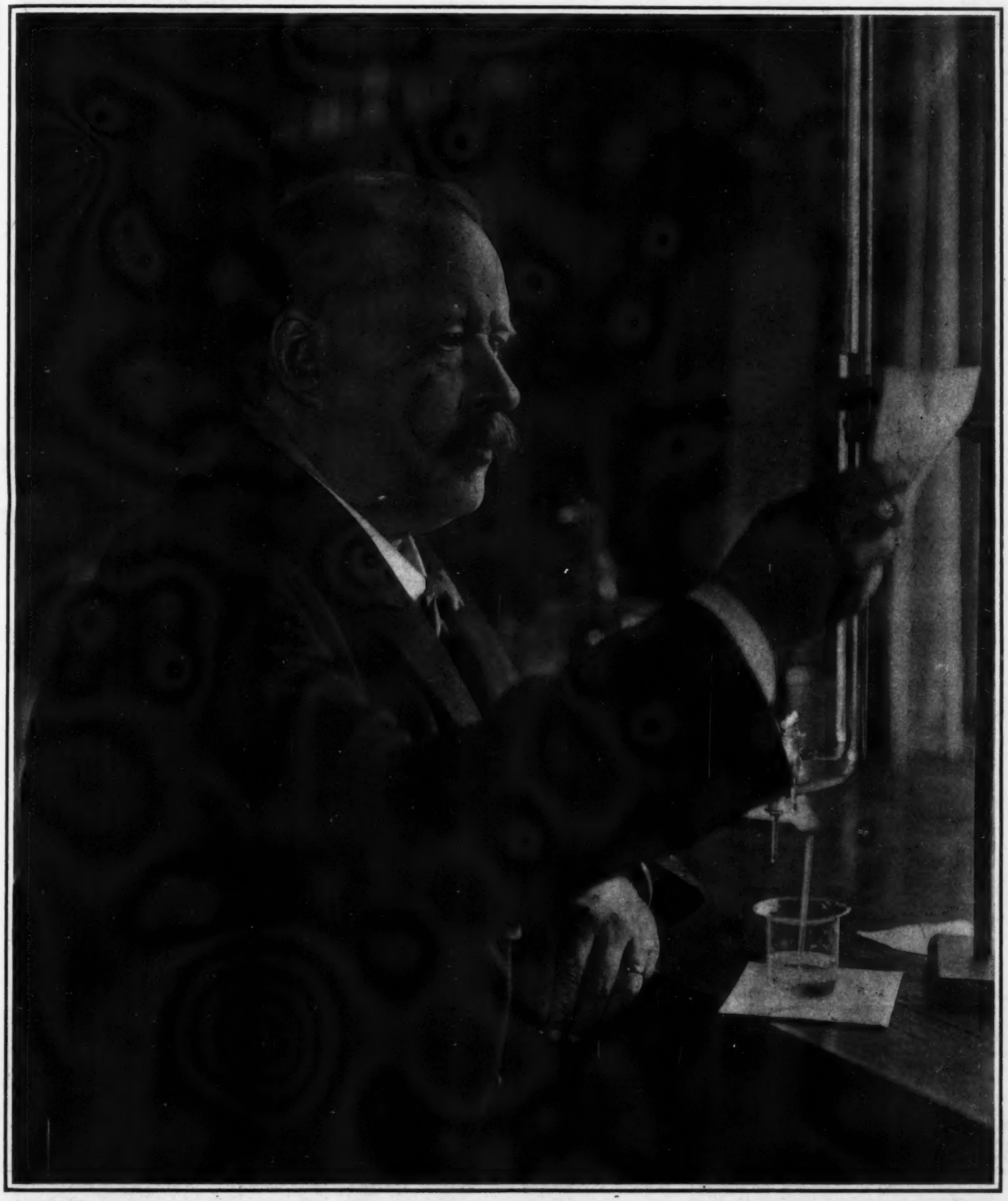

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Svante Arrhenius

THE WORK OF SVANTE ARRHENIUS.

A GREAT PHYSICIST AND CHEMIST.

BY THE BERLIN CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

It has often fallen to the lot of the genius not to be fully understood and appreciated by his contemporaries, especially by his own nation. This has been the lot of one of the most distinguished scientists of the present time—Svante Arrhenius, whose greatness has been recognized only lately by his own country, in fact, many years after other people had learned to appreciate him as the founder of modern electro-chemistry. The first official recognition of his merits was the awarding of the Nobel prize for chemistry to him in 1904. Owing to the ever-increasing importance of electro-chemistry for present-day industry, it will be interesting and instructive alike to cast a rapid glance at the life and work of this pioneer of science.

Arrhenius was born on the 19th of February, 1859. He has only just completed the fiftieth year of his life, and is still at a period of undiminished activity. After having commenced his scientific studies, mainly of physics, at the University of Upsala, he soon moved to Stockholm, with a view there to find a more congenial scientific atmosphere and better-appointed laboratories. At the scientific academy (Vetenskaps-Akademi) he soon commenced, as a pupil of the electrician Edlund, an investigation of the conductivity of electrolytes, which as early as 1883 led the experimenter to a conception of electrolytic dissociation mainly identical with that theory of his which has brought about so profound a revolution in our views on chemical and physical phenomena.

Though the fundamental principles of this theory are now widely known, it will perhaps not be amiss briefly to recall that the salts, acids, and any other electrolytes in solution are, according to it, considered as being partly dissociated into ions before the passage of any electric current. As these ideas were strikingly at variance with the notions then prevalent on the nature of chemical compounds, it will be readily understood that the judges of Arrhenius's inaugural dissertation (Récherches sur la Conductibilité galvanique des Electrolytes) at the University of Upsala should have been at a loss to gage its merits. While competent physicists spurned it as being out of their sphere, the professors of chemistry, who could not help reporting upon it, found, in their majority, a qualification extremely significant for their state of mind ("non sine laude approbatur").

It is gratifying, however, that one of the members of the minority, Prof. Pettersson, one year afterward—in December, 1884—published in a Scandinavian magazine a juster and more flattering appreciation of Arrhenius's work, of which the following is an abstract:

"When Lord Rayleigh, president of the British Association, at the meeting of 1884 said that 'from the further study of electrolysis we may expect to gain improved views as to the nature of chemical reactions, and of the forces concerned in bringing them about. . . . I cannot help thinking that the next great advance, of which we have already seen some foreshadowing, will come on this side,' he would have been able to base his hopes on the fact that the first rudiments of a rational chemical theory had already been created by Berzelius on an electrolytic basis." After then describing the drawbacks to this theory, which was mainly annihilated by Faraday's law (as according to it the same amount of electricity would dissolve in the most varied compounds the same number of valencies though the chemical forces had to be considered as of very different intensity) he suggests that the chemical forces acting in electrolytes be transformed to such a degree as not to be easily recognizable. Now, as by far the majority of reactions take place between electrolytes, "a theory of electrolytes would be practically identical with the theory of chemical conversions generally."

Investigating in his memoir the electrolytic condition of solutions, Arrhenius had adduced for discussion nearly any kind of well-studied phenomena by considering them from a common point of view and basing them, with striking clearness though daringly, on the Clausius-Williamson hypothesis.

Pettersson then goes on briefly to abstract the contents of Arrhenius's work:

"Both electrolysis and the Faraday law are accounted for on the equality of electrical charges of ions, the parallelism between the rate of reaction and ionic concentration being a further result for which striking evidence has been derived, e. g., from Ostwald's experiments on the conductivity of acids on one hand, and their inverting and catalyzing effects on the other. Prof. Ostwald states that, though the idea of ascertaining the intrinsic connection between these phenomena apparently so heterogeneous had long been present to the mind, the solution and actual priority was due exclusively to Dr. Arrhenius, whose work should be reckoned among the most important publications ever made on the theory of affinity."

Pettersson further draws attention to the "daring conclusion" by which Arrhenius had been led to his interpretation of neutralization heat and his deduction of chemical equilibria made, to Pettersson's best knowledge, independently of the Guldberg-Waage theory.

"Dr. Arrhenius especially excels in the art of utilizing for scientific purposes what is called dead material, while the material obtained by himself plays only a subordinate part in comparison with that derived from the researches of others for developing the theory." (It may be said in this connection that Arrhenius later in his life proved as brilliant in gathering for himself experimental data as a basis for scientific deduction.) After some criticism of the judgment pronounced by the University of Upsala, Pettersson concludes with the appreciation that some chapters in Arrhenius's work (e. g., the discovery of a connection between the conductivity and speed of reaction) "are in themselves worthy of the very highest qualification at the disposal of the faculty."

In spite of the brilliant manner in which he supported his thesis, Arrhenius, after the official verdict pronounced on his work, all but failed to be admitted as lecturer. Still, in 1884, he gained admission as lecturer in the branch of physical chemistry, which being then considered neither as chemistry nor as physics, was not reckoned among the official subjects. The scientific world of his country began to consider him as something of a savant only when the first official recognition had been awarded him when his great foreign colleague Ostwald, then professor of Riga University, paid him a visit in 1886. In fact, this event was considered so important in Arrhenius's town, that everybody congratulated him on what they regarded an unexpected distinction.

A few years were then spent abroad at the laboratories of some famous scientists (with Kohlrausch at Würzburg, Boltzmann at Graz, Ostwald at Leipzig, and Van't Hoff at Amsterdam) where he conducted all those brilliant investigations which time and again proved in the most varied manner the fertility and importance of the new ionic theory. But, strange to say, even these achievements failed to obtain for Arrhenius the scientific recognition he desired, and it was not before 1891 (after his younger colleague Angström had resigned his post as co-ordinate teacher of physics at the private university of Stockholm) that Arrhenius, not without difficulty, and only after refusing a call to Giessen University, succeeded in obtaining this modest position at the Swedish capital. Far greater difficulties were to be overcome when, in 1895, his post was to be converted into a definite professorate. Though nobody dared to compete with him in this connection, some intriguers succeeded in having Arrhenius submitted to the humiliating appreciation of his competence by a committee consisting of Lord Kelvin, Dr. Hasselberg, a Swede, and Christiansen, a Dane. The latter pronounced a most enthusiastic judgment on the man whose competence, he said, was so generally recognized that he, independently of any other candidates, would have been the only one fit for the post. Lord Kelvin, however, took exception in very energetic language against the theory of ions, and Hasselberg delivered a certificate according to which the works of Arrhenius were "not physical enough" to attribute him the desired competence. These decisions, however, made a greater stir than their authors might have expected; and when Prof. Ostwald had voiced his indignation in very strong terms, the University of Stockholm, fearing a scientific scandal, hastened to invest Arrhenius with the professorate of physics about the very time of his being made an honorary member of the German Bunsen Society.

Nor was this the last opposition Arrhenius had to overcome in his scientific career; for when discussing in 1901, at an unduly late period, Arrhenius's membership of the Swedish Academy of Science (where Angström, the younger man, had received precedence) the academy nearly exposed itself to universal condemnation by further ignoring this greatest of Swedish scientists.

Arrhenius thus has only lately begun to be fully appreciated in his country, after the epoch-making work of his life has won him universal fame. This work is of a surprising variety, and besides the development of the theory of dissociation, comprises the most manifold problems of cosmical physics (northern lights, vulcanism, fluctuations of climate, atmospheric electricity, electricity of the moon, etc.). He has even published lately some remarkable papers of a biological character (cosmico-physical influences on maladies, diffusion of life in the universal spaces, serum immuno-chemistry).

Two recent books of exceptional interest on "The Evolution of Universes" and "Conceptions of the Universe in History" have won him unusual popularity in his native country, where people are at last beginning to be proud of their great compatriot.

The writer wishes to express his indebtedness to Prof. R. Abegg for courtesies shown him in preparing this article.

HUNGER AND MENTAL ACTIVITY.

A thorough exposition of the influence of hunger on mental activity was recently published, says a recent issue of L'Independance Belge. The author, M. Lassignardie, examines the mental conditions of a person who has been deprived of nourishment wholly or partially. Deprivation of nourishment may be various, however; for instance, first, voluntary deprivation for the purpose of spectacular endurance, as in the case of Succi, the professional faster; then compulsory deprivation, as in diseases, such as violent fevers, hysteria, and acute mental derangement, and also where hunger is a consequence of poverty, shipwreck, of imprisonment under *débris* in mines and other accidents, where hunger is continued for the commission of suicide, and finally in religious fasts.

One of the most interesting chapters of this distressful theme is the study of the transitory delirium that follows long deprivation, as after shipwreck. One of the author's friends, Dr. Maire, who was one of the victims of the shipwreck of the French ship, the "Ville de St. Nazaire," gives a luminous description of the delirium which he and his companions suffered in consequence of hunger. The conclusions of the book all converge upon the mind; if the deprivation does not last too long and if, especially, it is voluntary and habitual, the result is manifest activity of the mind, and particularly of the imagination. If the deprivation be protracted a change in the character and deportment of the person takes place, which is expressed by a peculiar excitability, by extraordinary selfishness, and by cruelty even. At the same time unequivocal signs of mental derangement appear, such as partial loss of memory, of volition, of self-control, and an inclination to sudden and irresistible impulses which seem to be wholly instinctive. In serious cases the mental derangement becomes particularly acute during the night; it shows itself in sleeplessness, in horrid dreams, nightmares, illusions, maniacal visions, and dangerous impulses. If mental derangement occur during the day also it indicates a very serious condition that can become extremely dangerous. If deprivation last indefinitely the victim, under the influence of continued hallucinations and irresistible impulses, can therefore be hastened to deeds such as occasionally filled the world with horror. Lassignardie draws a parallel between the mental condition resulting from hunger and that resulting from drunkenness; in both he finds the same disturbance of the intelligence, of *morale*, and of deportment. Clinical as well as experimental facts have shown that many of the signs of disease correspond precisely with those of the effect of deprivation of nourishment.

If aluminium bronze containing 6 per cent or more of aluminium and 20 per cent or less of manganese is fused and poured at a red heat into cold water or mercury, it is found to possess no magnetic properties whatever, but if the metal is then tempered by immersion in boiling toluol or xylol for a few hours it acquires its maximum magnetic permeability and exhibits exceedingly little or no hysteresis. If, on the other hand, the fused and red-hot alloy is allowed to cool slowly it shows some polarity, and on being tempered as before acquires approximately the same degree of permeability as in the former case, but it now exhibits hysteresis to a degree proportional to the slowness of the preliminary cooling. The metal can be caused to assume these different conditions repeatedly. The magnetic permeability of the alloy is influenced not only by its previous thermal history, but also, and still more strongly, by its chemical composition. The maximum permeability is exhibited by the combination Al, Mn, Cu_2. Heusler and Richarz, to whom these discoveries are due, are now studying the applicability of these alloys to the construction of electromagnetic apparatus, in which freedom from hysteresis is very desirable.

AN ANCIENT DUODECIMAL SYSTEM.*

BABYLONIAN CONCEPTIONS OF NUMBERS AND MEASURES.

BY RUFUS P. WILLIAMS.

"A PINT'S a pound the world around."

This aphorism is approximately true of water, so nearly true that it was regarded absolutely so by our ancestors. If a pint is a pound, then a quart weighs two pounds and 32 quarts or 64 pints weigh 64 pounds. But a cubic foot of water also weighs 64 pounds, hence a cubic foot was equivalent to 64 pints. Now the correlation of these three facts is interesting —64 pints, 64 pounds and one cubic foot of water are equivalent each to the other, or a cubic basin one foot long, wide, and high holds 64 pints, which weigh 64 pounds. Was this accidental, or was it design? In dry measure 32 quarts make a bushel. Dry and liquid measure were once the same in content, though now differing considerably. As it is the fact rather than the name we wish to emphasize, the word bushel is used in the following table. A linear foot was divided into 12 parts called inches, a square foot containing 144 square inches and a cubic foot 1,728 cubic inches.

The following table exhibits the successive dual divisions of the numbers mentioned:

1 bushel, or 64 pints, contains 1,728 cubic inches, and weighs 64 pounds.

½ bushel, or 32 pints, contains 864 cubic inches, and weighs 32 pounds.

¼ bushel, or 16 pints, contains 432 cubic inches, and weighs 16 pounds.

⅛ bushel, or 8 pints, contains 216 cubic inches, and weighs 8 pounds.

1/16 bushel, or 4 pints, contains 108 cubic inches, and weighs 4 pounds.

1/32 bushel, or 2 pints, contains 54 cubic inches, and weighs 2 pounds.

1/64 bushel, or 1 pint, contains 27 cubic inches, and weighs 1 pound.

It should be said that the 8 pints given above, or 216 cubic inches, are not the present imperial gallon, which contains 10 pounds of water, in which a "pint of pure water weighs a pound and a quarter."

Let us turn now to linear measure. The foot was divided into 12 equal parts called inches. Twelve is divisible by 2, 2, and 3. The cubic foot of 1,728 cubic inches is an extraordinarily good number to subdivide. Besides being a perfect cube it can be divided by 2, 2, 2, 2, 2, 2, 3, 3, 3, or $(2)^6 \times (3)^3$. It is divisible by the cube 64, giving a quotient of 27, another perfect cube. To repeat, the curious facts summarized in the above table are: 64 is divisible by 2 as many times as 1,728 is; 64 pints contain 1,728 cubic inches, or 1 pint is 27 cubic inches, and 1 pound (of water) also fills 27 cubic inches. These numbers, 12, 1,728, 64, 27, therefore, bear a peculiar relation to one another, and are the most perfect numbers to correlate in this manner which could have been selected, so perfect, in fact, that one cannot avoid the conclusion that some clever and practical mathematician invented this system of weights and measures, which is a combination of the duodecimal and dual systems. To contrast this system with the decimal let us suppose our philosopher had employed the decimal system and divided the foot into 10 inches. The cubic foot would have contained 1,000 cubic inches, which number is exactly divisible by 2 only three times instead of six times, as in case of the duodecimal 1,728. In the same way he could have divided 100 pints or 100 pounds by 2 only twice, instead of 6 times, as in the number actually used, 64. The following table illustrates the point:

1 bushel or 100 pints, or 1,000 cubic inches (water) would weigh 100 pounds.

½ bushel or 50 pints, or 500 cubic inches (water) would weigh 50 pounds.

¼ bushel or 25 pints, or 250 cubic inches (water) would weigh 25 pounds.

⅛ bushel or 12½ pints, or 125 cubic inches (water) would weigh 12½ pounds.

If he had called 1,000 cubic inches 1,000 pints and the weight 1,000 pounds, even then but 3 divisions by 2, instead of 6, could have been made. Looked at from this standpoint alone the duodecimal system of weights and measures, as well as of numbers, appears greatly superior to the decimal, but this is only one viewpoint, and takes no account of decimal notation.

Let us now try to imagine how this mathematical philosopher worked out his problem, for thus we may gain an insight into the origin of the duodecimal system. The foot was the starting point, and it was originally derived from the length of the pedal organ of some person, real or imaginary, as the foot measure was almost universal in early civilizations. Our philosopher, knowing the three dimensions of space and the relations of square and cubic to linear measure, conceived the idea of correlating also volumetric measure and weight to the lineal foot. Had he gone no further and disregarded subdivision, the decimal would have served equally well, and he would naturally have selected 10 as his unit, instead of 12. But, noting that the cubic foot of water (or wine) must be subdivided, he found from the multiplication table that no number up to 12 (with the possible exception of 8, which is an inferior number to 12 as a basis) would give a cube capable of such perfect subdivision successively by 2, as would 12. Twelve was therefore selected as a division of the foot, the smallest subdivision that at the time was deemed necessary. This quotient was called the inch (from the Latin word *uncia*, a twelfth part). In fact, the word shows the origin of the idea. Our word ounce is also a derivative of *uncia*, and means the twelfth part of a pound. A square foot must therefore contain 144 square inches, and a cubic foot, 1,728 cubic inches. Having found a number whose cube could be divided six times by two, he would naturally construct a 1,728-cubic inch basin, then make vessels containing successively the half, quarter, eighth, etc., parts, obtaining at last the conveniently small quantity—the pint. This was as low as it was carried, for it was the last dual subdivision of 1,728 and, further, it is a conveniently small volume of water or wine. The pint held 27 cubic inches.

Again, seeing the utility of correlating weight with volume, he counterpoised the pint of water and named its weight a pound (from *pondus*, a weight). Multiplying the pint and pound as many times as he repeated the 27 cubic inches, he arrived at 64, the whole secret of the combination being the selection of 1,728, or, rather, its cube root, 12. The early pound had 12 ounces, not 16. Thus did the ancient philosopher work out a most perfect duodecimal system of weights and measures.

Prof. Conant in his admirable work on "The Number Concept," as well as Lubbock and other anthropologists, have shown how strongly the decimal system of counts from the ten fingers persisted in most early races and formed the basis of our system of numbers. Had our savage ancestors chosen as wisely as the ancient philosopher, and counted 12 instead of 10 as a radix, the two would have invented as perfect a working system as the science of numbers admits. The savage chose not wisely, and the two systems, decimal and duodecimal, are as unblending as oil and water. To attempt to harness the duodecimal or any other system of weights and measures to a decimal notation is to break up the duality of both, one of which must eventually give way. When Herbert Spencer opposed the metric system on the ground that the duodecimal notation was better than the decimal and would some time supersede the latter, he could not have counted upon the hold that decimalization has taken on the whole human race.

Though we cannot name this Newton of antiquity, the inventor of so clever a system, we may with much probability trace his nationality. Our system, of course, was derived from England. Whence did she derive hers? Definite English laws about weights and measures take us back little further than 1266, when the second Magna Charta, relating largely to uniform weights, was forced from Henry III. So many changes have since been made in the subdivisions of these measures that it is difficult to recognize the Simon-pure article in the original. That these weights and measures came originally from the ancient Romans is shown alike by the similarity of derivation and their correlation. Their foot, for example, had the same origin as our own, though in the lapse of ages the English foot has become longer than its old prototype. The old Romans also correlated length and capacity measure by making a cubic foot of water or wine, and naming it an amphora. And, moreover, they called an eighth of an amphora a congius. For grain, etc., the term quadrantal was used, which, also, had the capacity of a cubic foot. Thus the amphora or quadrantal corresponded to our bushel, and the congius to our gallon. Owing to the shortness of their foot, the capacities of the above measures are not now coincident with those of our own, but this in no way affects the harmony of relation.

The Romans, however, were not a mathematical people. They employed letters—Roman numerals—in place of Arabic figures, as a result of which they never originated much in mathematics. Like the English, the Romans were borrowers. We have unquestionable evidence that their arithmetic came from Babylonia. Here in the valleys of the Tigris and Euphrates are now found the oldest known remains of civilization, extending back perhaps 5,000 years B. C. On slabs of baked clay are recorded the history of the times and of a people enlightened in mathematics and astronomy.

The versatility of Babylonian mathematicians is shown by their familiarity with the use of the dual, the duodecimal, and the sexagesimal systems, in addition to the decimal. To this people, then, we are led to believe we owe the once perfect duodecimal system of weights and measures.

But not alone were the Babylonians concerned with such measuring. Measurements of the circle, the year, the day, were problems which they solved and handed down to us. Whence came the sexagesimal system, in which 60 is the radix? Probably from two sources. First, from the division of the circle; second, from that of the year. Dividing the circle into six equal parts by three diameters, and connecting the extremities so as to form triangles, they found every angle equal to every other, every side equivalent to every other, every triangle equal to every other triangle. There were six of each of these, but while six was not a number to subdivide, its multiple by ten—that is, 60—is a fair one, and 360 for the entire circumference, a better one. Besides, this number most clearly corresponded to a complete yearly cycle, 360 days being the length of their year.

The parts of the circle 360 deg. cut off by the extremities of two consecutive diameters form a sixth part of the entire circumference, or 60 deg., called a sextant. Each of the sixty degrees was again divided into 60 parts called minutes, and each minute into 60 other parts called seconds. This sexagesimal system of the circle runs as follows:

Sixty seconds make one minute.
Sixty minutes make one degree.
Sixty degrees make one sextant.
Six sextants make one circumference.

The year was divided duodecimally into 12 months. The week is another question, not connected with our discussion.

Such was the Babylonian division of the circle and the year. But even more interesting is the division of the day, for in that they made use of the dual, the duodecimal, and the sexagesimal systems. A complete day, from one sunrise to the next, was divided into two parts, from sunrise to sunset, and from sunset to sunrise, or, into day and night. The day they divided into 12 parts, and the night the same, this being exactly true only at the vernal and autumnal equinoxes, with which the Babylonian astronomers were familiar. In subdividing the hour, recourse was again had to the sexagesimal system, as also in the division into minutes. Why 12 parts instead of 60 were made the day measure we can only guess, but in that conjecture we see how much simpler is reckoning by 12 than would have been by 60. The "time" table is too familiar to everyone to be repeated here, but twelve hours per day and 12 per night gave us the 24 hours per day. Most clocks, except astronomical ones and those of a few European railroads, are still marked off into 12 hours. The clepsydra, or water-clock—similar in principle to our sand-glass—served among the Mesopotamians, as among the Greeks and Romans, for marking the subdivisions of the day, though the sundial was also in use. Few things illustrate better the persistence of custom than the fact that we use the identical system of numbers which these people employed 5,000 years ago, for measuring time. Clever indeed was the mathematician who, so many years ago, invented the perfect system of duodecimal weights and measures, and wise the ruler who forced its use on the people.

The sexagesimal arithmetic has to a large extent disappeared, and the duodecimal is slowly following in its wake. The English people have probably never had the latter system in its purity, as did the inhabitants of the Euphrates and Tigris, but each system will eventually go out of existence, because neither is in harmony with the world-wide decimal scheme of numbers.

No one, unless he be a time-server, if he carefully studies the history of weighing and measuring, can doubt that the international metric system, founded on the universal notation, is the coming system. The mathematician of the distant future will read with amazement that early in the twentieth century there were so-called civilized people who used a system in which 5½, 272¼, and other equally absurd numbers were bases of reckoning—a system far inferior to that of the old Babylonians, 5,000 years earlier.

* School Science and Mathematics.

MAKING A GARDEN SEAT.

INSTRUCTIONS FOR THE AMATEUR.

BY A. C. HORTH.

THE essential point to consider in designing this popular garden object is stability, and although this is often associated with massive work, it does not follow that thick and heavy timber should be used. The main thing is to have sound joints, for with correct

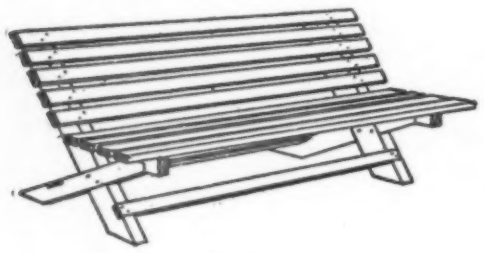


FIG. 1.

construction, great strength may be gained by the use of comparatively slender material.

The seat illustrated at Fig. 1 is an example of simple construction, utilizing the lapped halving joint only. The length may be anything from 3 feet to 10 feet, but for the purpose of estimating quantity of material required we will take a length of 5 feet. The seat should be about 15 inches wide and 17 inches above the ground, and the spread of the legs 21 inches.

Fig. 2 shows an end elevation of the trestle framing, and Fig. 3 gives the separate parts showing the grooves. The wood used for the above framing should be 3 x 2 inches, one length of 3 feet 4 inches, another 2 feet 6 inches, and a third 1 foot 7 inches being required for each frame.

The joint at the part where the two longer lengths cross each other should be at right angles to the sides and the groove, 3 inches wide, in the piece *A* should be 10½ inches up and at *B* 1 foot 3 inches up, and being a lapped halving joint the depth should be 1 inch. It will be advisable to cut these grooves first, place the pieces together and then mark out the position of the piece joining them *C*. This piece fits into the back *A*, but does not go halfway through, ¾ inch being quite sufficient. The end of piece *B* fits into it, being cut out, as shown at Fig. 3; in making this joint cut out to the shape shown at the end of *B* and then place in position on *C*. When it is fitted in the back mark out the shape. It will be impossible to saw this groove out, but with a wide chisel and a mallet cuts may be taken across the grain until the waste is cleared out. If this piece of work is beyond the skill of the worker, a slot may be cut right through the underside, as shown at *D*, Fig. 3, shortening the length of *B* to fit into the slot, which should not be more than ¾ inch deep.

When the joints are finished, this should be glued and pegged together, first boring a ¼-inch hole right through, and then inserting a round or octagonal length of oak previously dipped in glue.

Both trestles should exactly match, and when they are ready the bottom rails may be fitted in and the

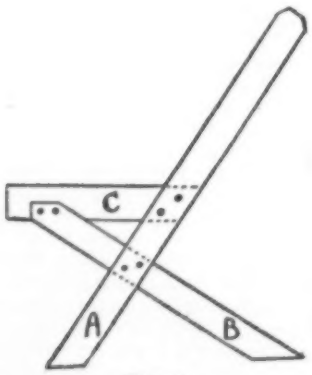


FIG. 2.

seat and back rail nailed or screwed in position. All the rails may be of 2½ x 1-inch wood, with the two top corners slightly chamfered, and altogether we shall require nine lengths each 5 feet long, and two lengths 4 feet 2 inches long for the two lower rails; the distance between the trestles being 4 feet 2 inches.

The following is a specification of the timber required:

For pieces *A*, two lengths, 3 feet 4 inches x 3 inches x 2 inches yellow deal.

For pieces *B*, two lengths, 2 feet 6 inches x 3 inches x 2 inches yellow deal.

For pieces *C*, two lengths, 1 foot 7 inches x 3 inches x 2 inches yellow deal.

For rails of seat and back, nine lengths, 5 feet x 2½ inches x 1 inch yellow deal.

For rails underneath, two lengths, 4 feet 2 inches x 2½ inches x 1 inch yellow deal.

In Fig. 4 is given a side elevation of the framing, shaped to make the seat more comfortable. The size of the framing in this case should be 3½ or 4 inches wide, but may only be 1¾ or 1½ inches thick. The rails should be the same thickness as those described above, but not above 1¼ or 1½ inches wide. The trestle ends should be jointed up in the same way as the plain seat, leaving the curves until all the joints have been cut and fitted together.

The curve is easily drawn, and when one is drawn out the shape should be sawn out carefully with a bow saw and finished with a spokeshave. The other end should be marked out from this, sawn out and shaped in the same way.

When both are done, prepare the rails or seat laths and either nail or screw them on. The number of laths required depends on the width, a space of ½ to ¾ inch being left between each.

For the benefit of those workers who would like to make arms to their seat, a diagram is given at Fig. 5, showing how this may be fitted. Wood of the same

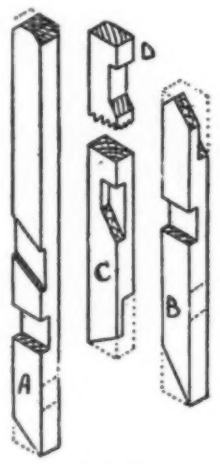


FIG. 3.

size as framing should be used, dovetailed or halved into the pieces *A* and *C* and joined at the corner by means of the stub mortise and tenon joint, the tenon being two-thirds the width and about half the distance through. Fig. 6 shows a section and a side view of this joint. The actual work of making the arms is not very difficult, for in the case of a curved seat the arm should be fitted in place before the shaping is done. The only difficulty likely to be experienced is

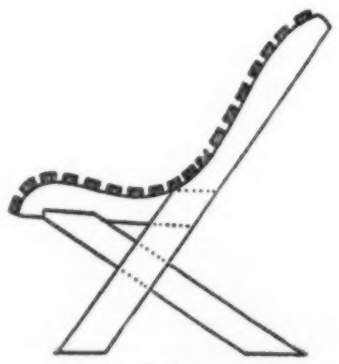


FIG. 4.

in fitting in the seat laths; these will have to be tenoned into their place where the arms join the framing.

A chair similar in shape to Fig. 1 may be easily made of rustic timber, small round logs or branches of larch being most suitable. For the trestle ends use the round stuff entirely, but for the seat and back laths smaller branches may be sawn down the middle and then lapped halved joints cut to fit them into the trestle ends, so that the flat portion is on top.

A small single chair suitable for the garden may be made in the same way as Fig. 1. Supposing the width to be 1 foot 6 inches, the trestle framing should be made of stuff about 2¼ x 1¼ inches, jointed up as shown above. The laths should not be more than ¾ inch thick and a width of 1¼ inches will be sufficient.

The above chairs could be made of oak or pitch pine and varnished, but if made of yellow deal, should be

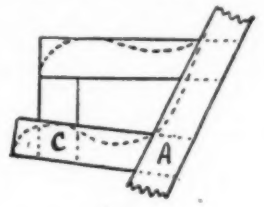


FIG. 5.

painted at least three coats before being exposed to all weathers.—Electrician and Mechanic.

HORSE-POWER FORMULA FOR AUTOMOBILE ENGINES.

THE horse-power formula for gasoline engines adopted by the Association of Licensed Automobile Manufacturers is

$$H.P. = \frac{D^2 N}{2.5}$$

where D = diameter of cylinder in inches,

N = number of cylinders.

According to a paper read by Mr. James L. Miller before the Glasgow Technical College Scientific Society, this formula gives, however, in general, an underestimate, especially for the larger sizes, and the following formula, which gives better results, is recommended:

$$H.P. = K \times D\,(D-1) \times (R+2) \times N.$$

In this formula

K = constant = 0.197 for commercial and touring cars and 0.33 for racing cars,

D = diameter in inches,

$R = \frac{\text{stroke in inches}}{\text{diameter in inches}}$ = ratio between stroke and bore,

N = number of cylinders.

Applying this formula to a four-cylinder engine with four inches diameter of cylinders and five inches stroke gives 31 horse-power, which could be obtained from such an engine at quite moderate speeds. The Automobile Manufacturers' formula gives in this case only 25.6 horse-power.—Machinery.

THE DISCOVERY OF OXYGEN.

THE eminent Danish chemist S. M. Jörgensen has published a book entitled "The Discovery of Oxygen," which forms a very interesting and valuable contribution to the history of chemistry. He cites various writings, now difficult of access, which show the early development of the belief in the complex nature of the atmosphere. But it was not until 1669 that an English physician, John Mayow, clearly expressed the view that a certain constituent of the atmosphere, *spiritus nitro-aereus* or *spiritus vitalis*, is also contained in

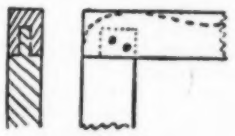


FIG. 6

saltpeter, certain acids and the *calx* produced by heating a metal in the air, and that it is this constituent of the atmosphere that sustains both combustion and respiration.

Oxygen was not isolated, however, until a century later, as a result of the labors of various investigators in the years 1771 to 1777. Scheele recognized the nature of oxygen in 1771 and is entitled to a large share in the honor of its discovery. Yet Priestley's actual separation of the gas from the *calx* (red oxide) of mercury, in 1774, was an entirely independent scientific achievement. Priestley's view of the reaction, however, was decidedly hazy and fantastic. The next prominent investigator in this field was Bayen, but the nature and properties of the new gas were first correctly demonstrated by Lavoisier.—Zeit. für angew. Chemie.

THE CALCULATION OF ELECTROMAGNETS.

SOME SIMPLE METHODS.

BY M. KENNETT.

THE action of almost every electrical appliance depends primarily upon magnetism. Consequently the elementary principles of electromagnets and the methods of calculating the size of the iron cores, and the winding of their exciting coils, should be of interest to every well-informed engineer. In spite of this fact, however, there is scarcely a piece of mechanism in the power station which is so little understood.

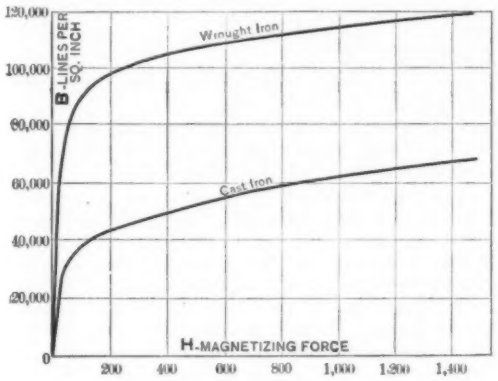


FIG. 1.

It has been known for a number of years that a wire through which a current of electricity is flowing is surrounded by a field of magnetic force, the intensity of which varies with the strength of the current flowing. For convenience in studying the phenomena of electromagnets, this field of magnetic force is conceived to be composed of imaginary lines of force circulating in a definite direction around the wire as a center, the number of these lines per square inch of cross section determining the strength of the magnetic field. If a long, straight wire is wound into a hollow coil, these lines of force circulating around each individual turn will, of course, be combined and will flow out of one end of the coil, through the air back to the other end, and will maintain this circulation through this circuit as long as the current of electricity is passing. If the strength of the electric current or the number of turns of wire is increased the number of lines of force is increased, and *vice versa*, if the strength of the current or the number of turns of wire is decreased the magnetic field becomes correspondingly weaker.

If an iron core is inserted in this coil the number of lines of force is increased wonderfully. For instance, a certain magnetizing force which produces 320 lines per square inch in air is found to produce as many as 103,000 lines per square inch in a certain specimen of iron. In other words, the iron is a very much better conductor of the lines of force than the air. This property of iron is known as permeability, and it differs in the various grades of iron and steel, pure soft iron having a higher permeability than the lower and harder grades.

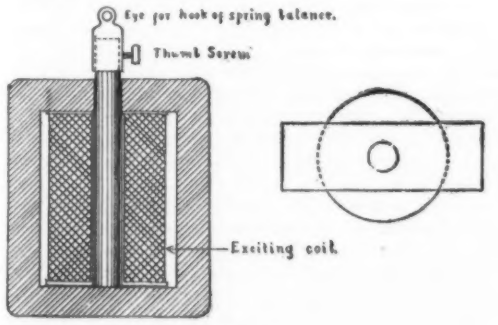


FIG. 2.

The law governing the flow of the lines of force in the magnetic circuit is similar to that governing the flow of the electric current in the electric circuit, although in order to avoid confusion, the terms used are somewhat different. Ohm's law for the electric circuit states that the strength of the current is equal to the electromotive force divided by the resistance, and for the magnetic circuit the law states that the strength of the magnetic field, or the number of lines of force per unit cross section, is equal to the magnetomotive force divided by the reluctance. The magnetomotive force is the force which tends to drive the lines of force through the circuit, and is represented by the product of the number of turns in the exciting coil and the number of amperes flowing through them; and the reluctance is the resistance which the circuit offers to the flow of the lines of force.

The object of this paper is to show how these various elements may be computed, so that the size and winding of a magnet may be determined in advance for any given result. For example, in designing a dynamo for a certain voltage at a given speed, the total number of lines of force which are to pass through the armature must be known before the winding of the armature can be determined. This involves the calculation of the size of the iron cores of the field magnets and the number of turns of wire in their exciting coils. Again, in designing a magnet which shall exert a given pull on its armature, the same calculations must be made.

The formulæ for all these calculations are based on what is known as the C. G. S. system of measurements, in which the centimeter and square centimeter are the standards. Most of the works on the subject discuss it in terms of the metric system, and for this reason are frequently confusing to the practical man who is accustomed to dealing with inches only. In this paper nothing but plain arithmetic will be used, and the formulæ have all been modified to deal with inches. An explanation of the derivation of the formulæ, however, would lead us into mathematics beyond the scope of this article and has consequently been omitted.

It is very evident that a piece of iron having a high permeability is more easily magnetized up to a given point than a piece of low permeability, and consequently this is one of the factors that must be determined before we can calculate the size or winding of a magnet for a given effect. The permeability of a given piece of iron is expressed by the ratio of the number of lines which a given magnetizing force produces in it, to the number of lines which it produces in air. For instance, in the specimen cited above, a certain magnetizing force produces 103,000 lines per square inch in iron, and only 320 lines per square inch in air. Therefore the permeability of that particular piece of iron at that stage of magnetization is

$$\mu = \frac{103{,}000}{320} = 322.$$

Hence we say the permeability of this iron at that stage of magnetization is 322.

You probably notice that we say "the permeability at this stage of magnetization" is 322. This is due to the fact that as the magnetization is forced higher and higher the iron approaches a state of magnetic saturation. In other words, it has practically reached the limit of its capacity to carry the lines of force. While it is true that literal saturation is never reached, a point is soon reached where an enormous addition of exciting force is required to produce a slight increase in the number of lines of force. Consequently for commercial reasons, it is not advisable to work the iron too near this point.

In studying the magnetic properties of iron the letter H is used to denote the number of lines induced per square inch in air, and the letter B is used to denote the number induced per square inch in the iron. Thus in the above case, the value of H is 320, and that of B is 103,000, and the permeability represented by the Greek character μ is,

$$\mu = \frac{B}{H} = 322.$$

The best way of illustrating the characteristics of the various grades of iron is in the form of curves, plotting the values of B vertically, and the values of H horizontally. Fig. 1 and the accompanying table, which are reproduced from one of Prof. S. P. Thompson's works, show such curves for a specimen of good wrought iron and gray cast iron. The curve for wrought iron is of the greater practical interest to us in designing comparatively small magnets, as we will do in this paper, and in designing larger machines the curve for cast iron is of value. Note how abruptly the curves rise as the values of H are increased slightly until the iron approaches a state of saturation at about 110,000 lines per square inch for wrought iron, and about 50,000 lines per square inch for cast iron. As stated above, it is not advisable to force the iron above this point as the increase in the exciting force is out of all proportion to the returns obtained. Consequently in the calculations to follow, the limit will be considered to be 100,000 for wrought iron, and 40,000 for cast iron.

Wrought Iron.			Cast Iron.		
B.	μ	H.	B.	μ	H.
30,000	4620	6.5	25,000	793	32.7
40,000	3877	10.3	30,000	756	39.7
50,000	3031	16.5	40,000	258	155.0
60,000	2159	27.8	50,000	114	439.0
70,000	1921	36.4	60,000	74	807.0
80,000	1409	56.8	70,000	40	1480.0
90,000	907	99.2			
100,000	408	245.0			
110,000	166	664.0			
120,000	76	1581.0			
130,000	35	3714.0			
140,000	27	5185.0			

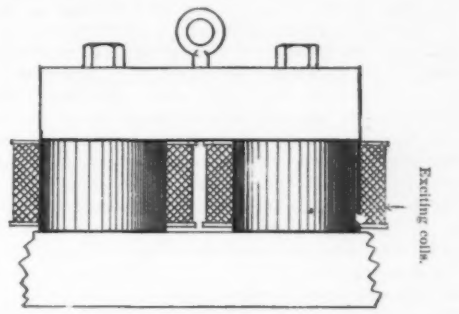


FIG. 3.

Fortunately the commercial iron used for such purposes does not differ materially in its magnetic qualities, so that by referring to some of the many permeability curves published, we can at a glance see what the permeability of the grade we intend to use is. In practice it is therefore unnecessary to make these tests in order to determine it. However, a brief outline of the method of making them may be of interest.

There are a number of methods of determining the permeability of iron, such as the ring method, the bar method, and several others. All require a more or less elaborate laboratory equipment, so that it is impossible to conduct them except in the laboratory. However, we are indebted to Prof. S. P. Thompson for a very simple method which does not require any delicate instruments, and which can be conducted in any ordinary testing room. As this is the simplest method, and for that reason the most likely to appeal to the practical man, we will give a brief description of it.

This system is based on the law of traction, which stated plainly, is, that the tractive force of a magnet, or the force with which it holds its armature in contact with the pole faces, varies as the area of contact

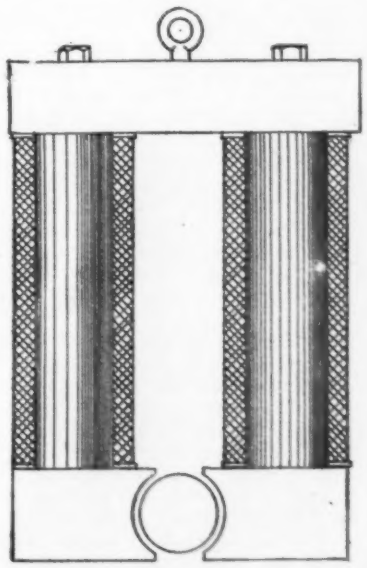


FIG. 4.

and as the square of the number of lines of force per square inch. The inventor has called it the "permeator" method, and for carrying it out a simple device, called the "permeator" and illustrated in Fig. 2, is used. It consists of a block of wrought iron slotted out to receive the magnetizing coil. At the top the block is bored to receive a rod of the iron to be tested, which has been carefully surfaced off on the lower face, and machined down to a known cross section; for instance, ¼ square inch. The rod is placed in

the permeator and a current of known strength, which is measured by an ampere meter in the circuit, is passed through the exciting coil, and the force necessary to detach it from the lower face of the block carefully noted on a spring balance.

Now, as we know the number of turns in the exciting coil and as we have measured the strength of the current passing through it, we have a means of calculating the magnetizing force, or the value of H, which as has been explained, is the number of lines per square inch in air. The formula for this is, for centimeter measurements $H = \frac{4\pi}{10} \times \frac{NI}{L}$, when H is the number of lines per square centimeter in air, N the number of turns in the exciting coil, L the length of the coil in centimeters, and I the strength of the exciting current in amperes. As this formula is based on the C. G. S. system, the measurements are all expressed in centimeters, and as we promised to deal only with inches, it is necessary to reduce it to inch measurement. One inch is equal to 2.54 centimeters, so that the number of lines passing through one square inch will be the square of 2.54 or 6.45 times as many as will pass through one square centimeter. Also as the length is expressed in centimeters, the most simple thing to do is to multiply the length in inches by 2.54. The formula now becomes $H = 6.45 \times \frac{4\pi}{10} \times \frac{NI}{2.54\,L}$

Thus by this formula we obtain the number of lines which the given magnetizing force will produce in air, and it remains for us only to find how many lines it will produce in the given specimen of iron.

We have seen from the law of traction that the force required to pull this rod of iron from the lower face of the permeator is proportional to the square of the number of lines passing through it. Consequently the number of lines varies as the square root of the traction. This gives us a means of getting at the total number of lines induced in the iron. The formula for this is $B = 8.494\sqrt{P \div A}$, when B is the number of lines per square inch in iron, P the pull in pounds required to detach the core, and A the area of the contact in square inches. Now having determined both A and B, the permeability is found by dividing the latter by the former, or $\mu = \frac{B}{H}$. As an example, suppose we had a permeator having an exciting coil of 400 turns and 6 inches long. The specimen of iron to be tested is ¼ inch square, thus having an area of 1/16 square inch. On passing a current of one ampere through the coil, it is found that seven pounds are required to detach the iron core from the lower face of the permeator. What is the permeability?

From the formula

$$H = 6.45 \times \frac{4\pi NI}{10\,L \times 2.54} = \frac{4 \times 3.1416 \times 400 \times 1}{10 \times 6 \times 2.54} = 212.$$

Also from the other formula, $B = 8{,}494\sqrt{P \div A} = 90{,}036$. The permeability, $\mu = \frac{90{,}036}{212} = 424$. By determining the values of H and B in the above manner for gradually increasing magnetizing forces, the curve of permeability is plotted.

As stated above, the lines of force circulate in a definite direction, flowing out of one end of the coil, back through the air or iron cores into the other end, maintaining this circulation as long as the magnet is energized. If the magnet is a straight bar the lines are obliged to return through the air, which is a very poor conductor of them, offering several hundred times as much resistance to their flow as an equal length of iron would. Consequently they should be provided with as nearly a closed iron magnetic circuit as possible. The familiar "horseshoe" type and its many modifications answer this requirement very well.

In all calculations pertaining to the electromagnet the reluctance must be the total reluctance of the entire circuit, including the iron cores, armature, yoke, and air gaps if there are any. Let us now see how to calculate the reluctance of a closed magnetic circuit, such as a horseshoe magnet with its armature attached. It is evident that this depends not only upon the length of the circuit, but also upon its cross section and conducting power, or the permeability of the cores. Now the permeability varies inversely as the number of lines flowing; that is, as more lines are forced through the iron, the permeability decreases. Consequently we must base all our calculations upon a given number of lines per square inch. Having decided upon this, say 100,000 which we found to be the practical limit for good wrought iron, we find by reference to our table that the permeability at this stage is about 408. Now, knowing the length and cross section of the circuit, we can substitute these values in the following formula: $R = \frac{L}{A \times \mu} \times 0.3132$

when R is the reluctance, L is the length of the circuit in inches, and A is the cross section of the circuit in square inches. The coefficient 0.3132 must be employed when inch measure is used. As an example, let us find the reluctance of the circuit of a horseshoe magnet in which the iron core is ½ inch square and the total length of the circuit is 10 inches, the value of B being assumed as 100,000. By substitution in the formula we have

$$R = \frac{10}{¼ \times 408} \times 0.3132 = 0.0307.$$

We have now arrived at the point where we can put our knowledge of these principles to some practical use by determining the size and winding of a magnet for any given result. As explained above, the magnetomotive force is the number of turns of wire in the exciting coil multiplied by the number of amperes flowing, and is usually called the ampere turns. The calculation of the ampere turns necessary to produce a given number of lines of force is a very simple matter. We have seen from our fundamental formula that $B = \frac{\text{ampere turns}}{\text{reluctance}}$, from which it follows that ampere-turns $= B \times R$. For instance, in the example just used, how many ampere-turns are necessary to drive 100,000 lines per square inch through this core of ½ inch square iron 10 inches long? As the area of the core is ¼ square inch, the total number of lines passing through it is one-fourth of 100,000 or 25,000, and as we have just found the reluctance to be 0.0307 the ampere turns will be 25,000 × 0.0307 = 767.5. In other words, it will require 767.5 turns when one ampere is flowing; or 76.75 turns at ten amperes, or any other combination which will give a product of amperes × turns = 767.5.

By reference to the curve of permeability it will be noticed that at 110,000 lines per square inch, or only 10,000 lines per square inch more, the iron is being worked pretty well on toward saturation. To emphasize this let us see how many ampere turns will be necessary to force the value of B up to 110,000 lines in the above example. By reference to our table again it will be noticed that the permeability is a great deal lower at this stage, being only 165 instead of 408 as before. The reluctance is

$$\frac{10}{0.25 \times 165} \times 0.3132 = 0.075168,$$

and the ampere turns $= 0.075168 \times 27{,}500 = 2{,}067$ as against 767.5 for only 10,000 lines per square inch less. This means that at this stage of magnetization, for an increase of 10 per cent in the value of B, the magnetizing force must be increased 169 per cent, so that the advisability of working the iron well below saturation is clearly shown. Now to prove the correctness of our calculations, let us work the first problem backward and see what number of lines 767.5 ampere turns will produce through a reluctance of 0.0307. Of course it should be 100,000 per square inch, as that is what we assumed at the outset. Again turning to our fundamental formula, we see that $B = \frac{\text{ampere-turns}}{\text{reluctance}}$ or $\frac{767.5}{0.0307} = 25{,}000$ for a cross section of ¼ square inch, or 100,000 per square inch, so we see that our calculations were correct.

The most simple problem in the calculation of electromagnets is the design of one for a given traction, which, as stated above, is its ability to hold its armature in contact with the pole faces. As this is the most simple calculation, let us start with it and design such a magnet for a lifting power of, say 2,000 pounds. By studying the law of traction more deeply we find that the pull in pounds is equal to $\frac{B^2 \times A}{72{,}134{,}000}$ or the value of B is $\sqrt{\frac{P \times 72{,}134{,}000}{A}}$

So that for any pull per square inch it is an easy matter to find what the value of B must be, or for a given value of B it is a simple thing to find what the pull per square inch of pole face will be.

Assuming the value of B as 100,000 again, we find from this formula that we can support 138.6 pounds per square inch. Of course our magnet will be of the horseshoe type so that each pole will only have to support one-half of the load, or 1,000 pounds. By dividing 1,000 by 138.6 we get the size of the core as 7.2 square inches, or practically a round core 3 inches in diameter.

The length of the core should only be enough to hold the wire, as any additional length only adds to the reluctance of the circuit and is of no use. At this point we encounter a slight difficulty, which, however, is not as serious as it seems to be at first. This lies in the fact that we cannot tell yet how long the core must be to hold the wire, as we have not as yet calculated the number of turns of wire, and cannot do so until we know the length of the core, in order to calculate the reluctance. As we can not determine either one of these with exactness just yet we will have to use our judgment, and decide on a probable length and calculate from this the number of turns in the exciting coils, after which we can tell whether we can wind the required number of turns on the length of core which we have allowed or not. Perhaps we will have to change it, but after having made this calculation, we can judge the final length very closely. Let us start with the core shown in Fig. 3. The diameter of the core is already determined as 3 inches and the yoke must be of at least equal section, which condition will be fulfilled by making it 4 × 1¾ inches. We will probably be able to get the necessary number of turns of wire on the cores if they are 2 inches long; at any rate, let us try that length and we can then judge better how long they will have to be.

In calculating the reluctance, the average length must be used, as the length along the inner sides of the legs is much shorter than that along the outer sides, so we must base our calculations on the average length. In this case this is 10¼ inches. Referring to our formula, we see that the reluctance is $R = \frac{L}{A \times \mu} \times 0.3132$. At 100,000 lines per square inch the value of μ is 408 and the equation becomes

$$R = \frac{10¼}{408 \times 7.06} \times 0.3132 = 0.001112.$$

We are now ready to calculate the number of ampere turns, the formula for which is ampere-turns $= N \times R$ when N equals the total number of lines passing through the entire core. Substituting in the formula we get ampere-turns = 706,000 × 0.001112 = 785. Let us agree to energize this magnet with a current of one ampere, then we will have to wind it with 785 turns or 392 turns on each leg. No. 21 wire will carry this current with only very moderate heating, and in winding a coil we can just get 26 turns of this wire in a length of one inch, so on a core two inches long we can get 52 turns, and seven and one-half layers will be required for the total of 392 turns. This will make the coils only about ¼ inch deep, which is by no means a deep coil, and we see that we could have made the cores much shorter, thus saving in the weight of the iron and in the magnetic reluctance, although the weight of copper would have been greater owing to the increased length of wire per turn in the outer layers. As a matter of fact the cores need not be more than one inch in length, but this will make so little difference that we may neglect the decreased reluctance, and wind them with 785 turns, making them about ½ inch deep, which is about right.

From this simple calculation it will be seen that it is not a difficult matter to compute the winding and dimensions of a magnet for a given effect when the magnetic circuit is closed, but this is not the case in most of the problems met with in practice. For instance, in the magnetic circuit of a dynamo there are air gaps between the armature and the pole pieces. This complicates the case greatly for several reasons. The reluctance of air is very much greater than that of iron, and this means that in order to force the lines of force through this great reluctance we must provide many more ampere turns. Another and very important consideration is that when this great reluctance is introduced into the circuit, a number of the lines will short-circuit across from one pole to the other without passing through the armature. This is called leakage, and it is impossible to calculate it with any degree of accuracy as it depends upon so many factors. Roughly speaking, however, it may be considered as about one-fourth the total number of lines in many dynamos, and it is customary to allow for it by employing a coefficient of leakage, which in the above case would be 0.25, and designing the magnet for that additional number of lines.

As an example, suppose we were called upon to design the field magnets for the machine represented in Fig. 4.

Let us assume that in order to generate the required voltage at the designated speed, 3,200,000 lines of force must pass through the armature, and the leakage is 25 per cent, so that the total number of lines passing through the cores must be 4,000,000 lines. Let the machine be of the following dimensions:

Area of pole faces, 12 × 6 inches or 72 square inches.

Diameter of armature, 6 inches.

Diameter of magnet cores, 8 inches or 50 square inches.

Thickness of air gaps, ⅜ inch.

Total length of magnetic circuit through iron, 69 inches.

Total length of magnetic circuit through air, ¾ inch.

We simply calculate the ampere turns required to drive the necessary lines of force through the iron cores the same as we did for the traction magnet, and then calculate the ampere turns necessary for the air

gaps, and add these together. As the total number of lines through the cores is to be 4,000,000 and the cross section of the cores is 50 square inches, the value of B is 80,000 lines per square inch. The permeability corresponding to this value of B is 1,409 and the reluctance of the iron circuit is

$$R = \frac{69}{50 \times 1{,}409} \times 0.3132 = 0.000306$$

and the ampere turns equal 4,000,000 × 0.000306 = 1,224.

We will now consider the air gaps. Remember that the leakage reduces the number of lines here by 25 per cent, so we only have to provide for 3,200,000 lines. The permeability of air is 1 and the cross section of the circuit at this point is 72 square inches, consequently the reluctance of the two gaps is

$$R = \frac{0.75}{72 \times 1} \times 0.3132 = 0.00326$$

and the ampere turns equal 3,200,000 × 0.00326 = 10,432. The total for the entire circuit is the sum of these, or 11,656 ampere turns.

To have been strictly correct, we should have calculated the ampere turns for the armature separately, as the decreased number of lines through it will reduce the excitation somewhat, but the difference will be so slight that in practice we may neglect it.

Let us assume that the exciting current is to be one ampere. This will call for 5,720 turns on each leg. We found that No. 21 wire would be the proper size for this current, and that we can wind 26 turns to the inch, so that, as the cores are 20 inches long, one layer will contain 520 turns, and 11 layers will give us a little more than the required number of turns. Of course it is impossible to calculate the winding of a magnet with absolute accuracy, as there are so many factors which may cause the results to vary somewhat. Any slight error of this sort may, however, be compensated for by varying the exciting current by means of the field rheostat.

In this paper, which is necessarily brief, the several points have been touched upon very lightly, and those who are interested are referred to the more advanced works on the subject.

LONG-DISTANCE TELEGRAPHY.*

A FEW EUROPEAN AND ASIATIC ACHIEVEMENTS.

FIFTY years ago, or more, it was the writer's privilege to assist at Edinburgh in the direct transmission of a royal message between Balmoral and Potsdam. The event took place on a fine summer Sunday morning, when the lines were quiet and the atmosphere was calm and highly conducive to the passage of the electric current. The Morse embosser had not long before taken the place of the Cooke and Wheatstone double needle; and the click of the armature enabled us to hear whether the signals were going through all right. The embosser was, indeed, a very good "sounder," although it was not until many years after that that form of instrument was adopted for general use. The wire was in relay at Edinburgh, the primitive windmill or "mouse-mill" form of relay being in use—a very simple contrivance compared with the elaborate "translator" of to-day. The experiment was carried out under the direction of Mr. Cromwell Fleetwood Varley, electrician of the Electric and International Telegraph Company, one of the most prominent scientists of his day, whose ingenuity in the matter of telegraphic invention was amazing. One of Mr. Varley's staff was at Balmoral, and my old countryman and *confrère* David Lumsden was at Amsterdam, where the electric company had an office at that time, which was designated "English Amsterdam" to distinguish it from the Dutch office.

The experiment was successful, the message going through without a hitch; and we all plumed ourselves on being associated, however remotely, with such a marvelous feat of telegraphy. And it *was* a feat for that day, although it pales into insignificance with what has recently been accomplished by the Indo-European Telegraph Company, or even with what takes place every day between the Foreign Gallery at St. Martin's-le-Grand and the more distant capitals of Europe. Here, however, the progress is not so great as it seems, for the late Sir Henry Fischer used to tell how, on Sundays, he would amuse himself when on duty at "old F. G.," in Founder's Court, Lothbury, by getting through to St. Petersburg or Constantinople, and having a chat with "Sir Bruin" or the "Unspeakable Turk," as the case might be. And yet, not long before, messages between Edinburgh and London might have to be retransmitted half a dozen times in bad weather, when the insulation went to pieces.

The cable companies have been reproached for want of enterprise in the adoption of improved methods of transmission, and for constituting themselves a "ring" in order to maintain the present high rates for telegrams passing over their lines. Be this as it may, the reproach does not lie very heavily at the door of the Indo-European Company, which has taken the lead in the matter of long-distance telegraphy, and is likely to maintain, if not to improve, its position in that respect. A year or two ago, by the adoption of the Wheatstone automatic system, it set up direct working between Manchester and London and Teheran, a distance of nearly four thousand miles, which was a world's record at that time. Now it has beaten its own record, and pushed through to Calcutta, between which and London, a distance of seven thousand miles, messages were exchanged on a Saturday toward the end of January last. This is a most notable achievement, to put it in the mildest possible form—an achievement which even a Kelvin or a Varley or a Wheatstone would have deemed impossible a quarter of a century ago, and which the present writer, familiar with all the improvements of the past half century, looks upon as almost uncanny. Of course it has only been rendered possible by the free use of relays, of which there are no fewer than thirteen in circuit between London and Kurrachee, and one between Kurrachee and Calcutta, at Agra. The clerks at these lonely outposts, scattered among the barren steppes of Russia and through the great Persian lone land, must lead an eerie life, as they sit in their huts listening to the hum of the world as it passes from the Far East to the distant West, and *vice versa*. The idea of the relay is no doubt taken from the old coaching days; but there is this essential difference, that the coaches pulled up for change and refreshment, whereas the electric current speeds along and takes up its "refreshment" as it goes, more closely resembling the locomotive which scoops up its water from between the rails as it careers along at fifty or sixty miles an hour.

Cables do not enter very largely into the operations of the Indo-European Company, being confined to a length of some two hundred miles between Lowestoft and Emden, beyond which, by way of Berlin, Warsaw, Odessa, and Tiflis, a land line is carried to Teheran. This is probably as wild a stretch of country as exists anywhere, and the climatic conditions are of the worst possible character, so that the delicate operation of telegraphing by means of relays through seven thousand miles of line becomes the more remarkable. Beyond Teheran the difficulties are not less serious, although of a different character perhaps. Here the line passes through unsettled country, swarming with hostile tribes who look upon it with suspicion rather than with awe; and the utmost vigilance on the part of the engineers and patrols is necessary to maintain it in working order. Compared with a cable lying comfortably at the bottom of the sea, the maintenance of a land line carried through a foreign country some thousands of miles distant from the base of operations is an anxious as well as a costly undertaking. Nor is the costliness of telegraphing to the Far East likely to be greatly mitigated by this system of direct communication, because, while transmitting stations have been eliminated, relay stations have had to be set up. The gain to commerce will be in increased speed and accuracy of transmission, two most essential points in telegraphy; and the rest may be safely left to Mr. Stratford Andrews, managing director of the Indo-European Company, to whose well-directed skill and enterprise these marvelous achievements are due.

Those who, in their innocence, think that wireless telegraphy, so called, is destined to supersede cables should ponder the history of long-distance telegraphy, which has ever been associated with the continuous wire, whether inclosed in a cable or carried overland. The current passes as readily out of the cable into the open wire, and *vice versa*, as though they were one, and this it is which has made long-distance telegraphy possible on a scale never dreamt of by the pioneers of the cable system. The great problem with the early inventors of the telegraph was "how to tie the current to a wire"; but the problem with the wireless people is how to let it loose, so that it may career over the face of the globe for anyone to catch hold of! Even at sea, where the system has undoubted advantages, any ship within radius may help itself to the messages knocking about; and although this was a mercy in the case of the wreck of the "Republic" it might be far otherwise in the case of ships of war at close quarters with the enemy. There is great trouble at Aldershot, where there is a powerful wireless station, through messages coming to hand from all quarters not intended for them, and some curious stories are told of the vagaries of the system. Wireless waves from Berlin have been received, and it is known that the Aldershot waves have been taken up by the German wireless stations, so that there is a constant tapping of messages not intended for the Aldershot station. During the troubles at Casa Blanca the wireless messages sent by the French warships to the station on the Eiffel Tower in Paris were received by the British warships at Dover and passed on to Aldershot! American millionaires, fired by the exploits of Binns of "Republic" fame, have set up costly installations along the coast, near New York, as playthings for their sons, and to such an extent has the nuisance grown that legislation has been demanded to put a stop to it. This only proves what has been foreseen by practical telegraphists from the first, that the more the system is extended the less efficient it becomes; and if to this we add that it lacks the great essentials of speed, security, and secrecy, we shall see that it can never become of any real value for commercial purposes, although it may continue to excite interest as a scientific curiosity. Secrecy is of the very essence of all telegraphy; but there can be no secrecy where messages are thrust violently into the air, to be picked up by the first eavesdropper who comes along.

* Chambers's Journal.

THE POPULAR ELECTRICAL LABORATORY OF BRUSSELS.

DR. R. GOLDSCHMIDT has established at Brussels an electrical laboratory of entirely novel character. Convinced of the insufficiency of books and oral explanations to give a satisfactory popular idea of the elements of an essentially experimental science like electricity, Goldschmidt desired to place experiment within the reach of everyone. For this purpose, he has established a popular laboratory of remarkably simple arrangement, where everyone, even the common workman, may familiarize himself, first, with elementary notions and, afterward, with more complex problems. The founder's contention, evidently, would not have been realized by the formation of a museum of electrical discoveries and inventions, for this would have been no more than a book, lavishly illustrated, it is true, but still not easily understood. Goldschmidt desired to show, not the crystallized science of the printed page, but science in life and action. He desired to initiate the visitor into the secret of experimentation, showing him the problem and solution at once. For this purpose it was necessary to so arrange the experiments as to make them all comprehensible—a difficult task—to establish a logical classification of experiments properly graduated and co-ordinated, to make the experiments performable by everyone, and to invent and construct a variety of simple, strong, and efficient apparatus.

Starting from this principle, Goldschmidt installed on the ground floor those fundamental experiments which form the basis of modern electrical science and which can be performed with comparatively simple apparatus. Here the visitor passes from the lodestone to the properties of magnets and electro-magnets and the explanation of electric motors; from the electricity of friction of glass or sealing-wax, to the operation of the Wimshurst machine, which is equivalent in effect to the induction coil found in another department, to electrical discharges in different media, cathode rays, radium, etc.

In the first story is the apparatus required for the demonstration of the principles of electro-dynamics, induction, alternating currents, and electrical measurements. Each instrument in these two sections is insulated within a glazed cage, as far as possible. In three adjoining rooms are collected instruments of precision and measurement, the operation of which requires a thorough acquaintance with all that have preceded them in the course. Here are photometers, Wheatstone bridges, resistance coils and other standards, galvanometers, wattmeters, etc. On the ground floor, in the center of the building, are installed the instruments which illustrate the construction of motors and dynamos. The character of these two sections differs a little from that of the preceding. The visitor finds himself in a laboratory where he sees measurements and experiments made by competent persons attached to the Bureau of Electrical Installations, which has

its office in the same building. Although following and understanding these experiments, he is, in general, incapable of repeating them. If, however, a sufficiently instructed visitor so desires, he will be permitted to experiment under the supervision of an expert. There is also a lecture hall equipped with projecting apparatus which, by the simple pressure of a button, exhibits a hundred pictures of scientific novelties. A room is reserved for manufacturers, in which they can show their products without charge, and there are four small laboratories which can be obtained by specialists for individual researches. The library contains the principal books and periodicals which deal with electrical matters. A workshop of precision enables the student to acquire practical knowledge of the construction of electrical apparatus. This institution, the result of the assiduous efforts of the past five years, has not yet assumed its final form, but Dr. Goldschmidt's beginning is extremely interesting. It exhibits a fertile idea, which is deserving of the greatest attention.—La Nature.

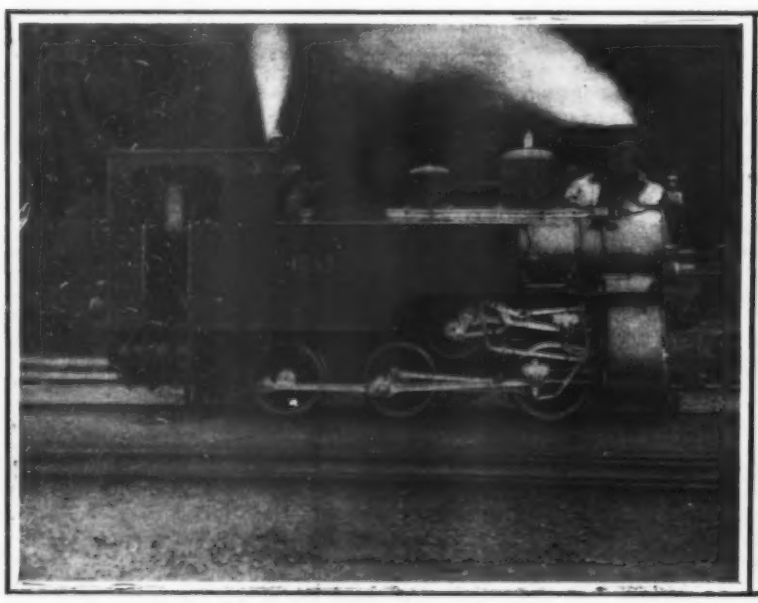
A SWISS MOUNTAIN ENGINE.

HOW INGENUITY OVERCAME A GREAT DIFFICULTY.

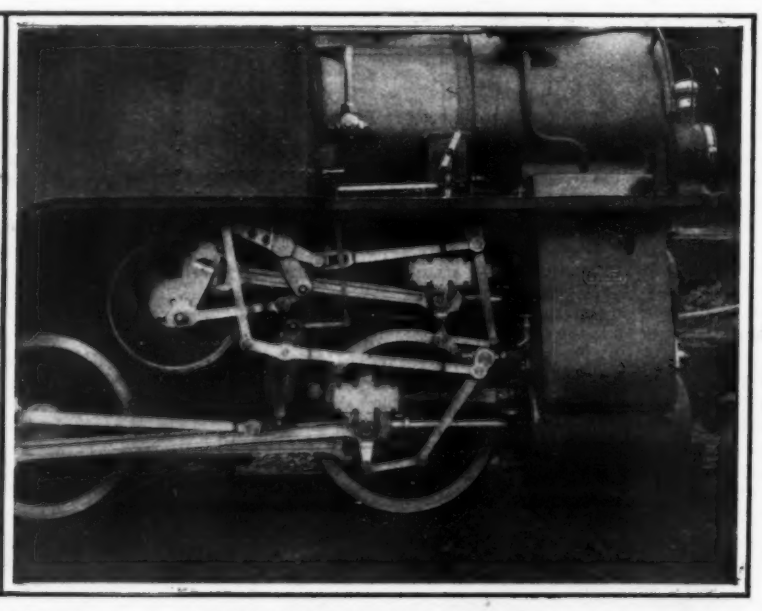
A CORRESPONDENT sends us the accompanying photographs of an engine, which he observed while on a walking tour in Switzerland, showing the ingenuity of the Swiss engineers in overcoming the exceptional difficulty of their service. The engine combines gravity adhesion for use on the level and small gradients with rack gearing for use in climbing the steeper grades. It is used on the rack railway over the Brunig Pass between Giswil and Meiringen, and was built at the Winterthur works of the Swiss railways.

The engine runs on the standard meter gage, the adhesion driving wheels being 910 millimeters (35.8 inches) operated by cylinders of 380 millimeters (15 inches) bore and 450 millimeters (17¾ inches) stroke, with a wheel base of 3.1 meter (10.2 feet).

The large pinion, engaging the rack, clearly shown in the illustrations, is 860 millimeters (33.9 inches) and is driven by separate cylinders of the same dimensions as those of the adhesion drivers, with transmission gearing intervening proportioned as 1 : 2. The tubular boiler is 2.675 meters (105 inches) long and 1.15 meters (45 inches) in diameter; the total weight of the engine light being 25,630 kilogrammes (28.5 tons). The tank capacity is 3,100 liters (818.6 gallons) and the coal capacity 1,000 kilogrammes (2,204 pounds), making the working weight 31,779 kilogrammes (35 tons), with which a tractive effort of 15,000 kilogrammes (16.5 tons) is obtained, the pull with rack and pinion being 11,000 kilogrammes (12.1 tons).



GENERAL VIEW OF THE LOCOMOTIVE.



DETAILS OF THE DRIVING MECHANISM.

Photos by R. C. Barrows.

A SWISS MOUNTAIN ENGINE.

FACTS ONE SHOULD KNOW ABOUT A GAS ENGINE.

By L. H. SNYDER.

To be able to converse intelligently and write on the subject of gas engines, one should be familiar with the everyday expressions and terms that he will encounter, also a few things worth considering in purchasing a gas engine and its care.

Horse-Power.—This is a comparison or relation, and was established by James Watt as the power of a strong London draft horse working a short interval, and was used by him to measure the power of steam engines, and is equivalent to the continual lifting of 550 pounds a foot a second. A boy can exert 1 horse-power if he can move fast enough, illustrated as follows:

Say he weighs 110 pounds and can run in one second up a flight of stairs which is just 5 feet in perpendicular height above the starting point; he will have lifted the equivalent of 550 pounds 1 foot in one second.

There are two horse-power ratings which a gas engine has, and one should be careful that he thoroughly understands just what they mean.

The indicated horse-power, often written I. H. P., means the power which an engine is capable of developing in the cylinders. It is obtained from the following formula:

$$P\ L\ A\ N \div 33{,}000$$

33,000 is a constant and is the number of pounds that would have to be lifted in a minute (550×60). P is known as the mean effective pressure, written M. E. P. This is obtained by means of an indicator and a planimeter. The indicator reproduces graphically the exact operation of a complete cycle of the gas engine. L is the length of the stroke in feet, A the area of the piston in square inches, and N the number of explosions per minute.

From the above, it can be readily seen that the above rating would be a builder's rating, and is the one generally used by them.

One may roughly determine the I. H. P. of a gas engine by the following formula:

$$\text{I. H. P.} = \frac{D^2 \times S \times N}{12.5}$$

where D is the diameter of the piston in inches, S the length of stroke in inches, and N the number of cylinders. This is based upon the assumption that the engine will make one thousand revolutions a minute and is a 4-cycle; also the assumption is made that the average M. E. P. is 80 pounds per square inch.

A formula which is often used is:

$$\text{I. H. P.} = \frac{D^2 \times N}{2.5}$$

The writer prefers the first formula, as it takes into account the length of stroke.

If the engine is a 2-cycle one, it is the rule to take the I. H. P. as two-thirds of the above formula.

D. H. P. (developed horse-power) is the horse-power that the engine actually delivers and may be measured by means of a Prony brake. This consists of a strap fastened around a wheel and attached to an arm with an adjustment for tightening and loosening the strap. The arm should rest upon a standard placed on a scale. It will be necessary to determine the constant. This is done by revolving the wheel forward and then backward, noting the reading upon the scale in both instances. These should be added and divided by two. The scale should be set so that it exactly balances the maximum tension that you can get upon the brake band without stopping the engine, and the scale reading noted. Deduct from this the value obtained by rotating the engine forward and backward, as indicated above, and use the following formula:

$$(6.28 \times G \times N \times A) \div 33{,}000$$

where G is the reading on the scale (after making the deduction as indicated), A the length of arm from the center of the flywheel to the point of contact on the scale in feet, N the number of revolutions per minute. This will give the horse-power the engine is capable of delivering.

$$\text{The mechanical efficiency is} = \frac{\text{D. H. P.}}{\text{I. H. P.}}$$

Compression.—After a mixture of gas and air is drawn into the engine (the third stroke in a 4-cycle engine and the second in a 2-cycle engine) it is compressed, and the intensity of violence of the explosion depends upon the compression.

There are two methods used to obtain a high compression. First, to make the compression space very small. Second, a tight fit between the piston and cylinders.

Leaky compression is caused by fouled piston rings or a poor fit between the piston and cylinder walls. Conditions are always better where flake graphite is used with the lubricating oil.

The object of the flake graphite is to attach itself to the minute irregularities which exist in the metal surfaces, building up a graphite to graphite coating of marvelous smoothness.

Where splash lubrication is employed, the graphite may be put into the crankcase in the proportions of about a teaspoonful to pint of oil.

I know of a gentleman using flake graphite in his automobile engine and he is able to start on compression after standing for over forty-eight hours. He was not able to do this before he used graphite.

Sometimes a false head is put into a clearance space to decrease it, thereby making higher compression. This should be done only by a competent person, as it may increase the compression so high that the engine parts will not stand the strain or there may be serious back-firing.

When purchasing a gasoline engine, one should test the compression by closing the pet cock and turning the engine over. Where there is more than one cylinder, try one at a time with the pet cocks on the others open.

In starting gasoline engines, start on a lean mixture and gradually increase its richness until the proper amount is reached. This experience will teach.

Have the spark adjusted so that the engine is fired at just the right part of the stroke. A rough rule is about one-quarter stroke.

A smoky exhaust indicates there is too rich fuel or too much lubricating oil; a white, smoky exhaust shows too much lubricating oil, while a black, smoky exhaust shows too much gasoline.

In shutting down, close off the fuel supply first, then open the switch.—Gas Review.

RAPID TRANSIT IN THE FUTURE.

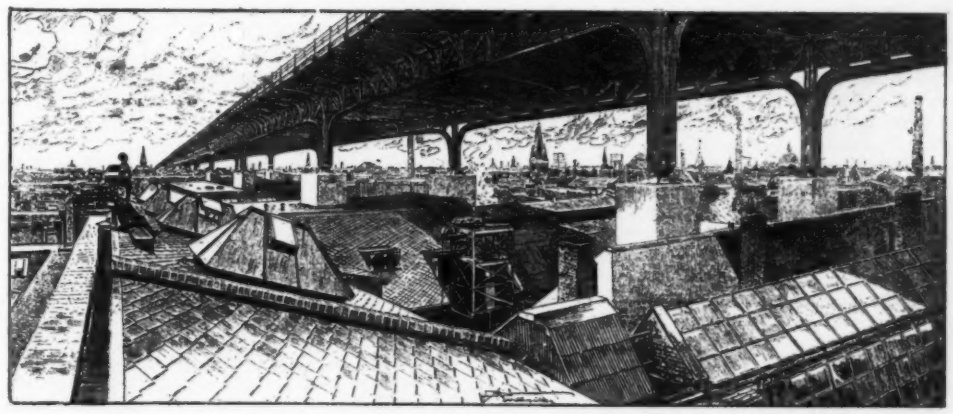
AUGUST SCHERL'S PLAN.

IT is a well-recognized fact that our present railway systems are very inadequate to the demands of modern traffic. The reason of this is to be sought in the development of the railways. When railways were first constructed, in the first part of the nineteenth century, they were not regarded from a progressive point of view even by their inaugurators. The characteristic of this is the celebrated remark of the postmaster of Berlin, to the effect that no railway was needed between Berlin and Potsdam, because even the post coach was not always fully occupied. So the railway systems developed under the control of petty views and special interests, and from this condition of things we are still suffering. For example, the gage of our railway tracks is that of the old English post-coach, and the international express trains, which connect the north and south of Europe, are compelled to stop at many small towns in accordance with ancient arrangements with petty states. A great many railway men and financiers have studied the question of reform, without finding a satisfactory solution. The latest proposition is that of the well-known Berlin publisher, August Scherl, who has often attracted public attention by his ideas and suggestions in other matters. In a volume richly illustrated with drawings, plans, and tables, Scherl has expressed his views on the reformation of railway traffic. These views, if not always very original, contain much that is interesting and of practical utility.

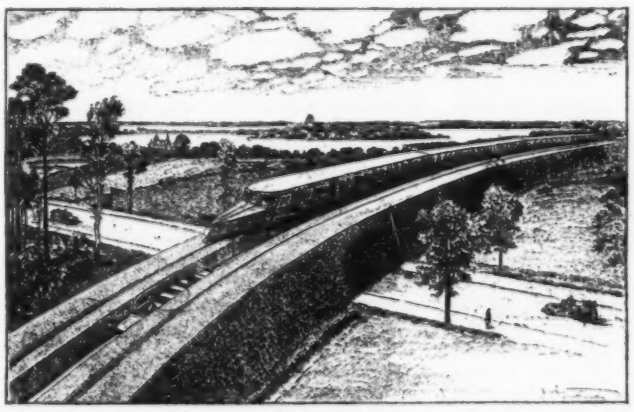
Scherl starts from the correct assumption that the greatest obstacle to the rapid conveyance of passengers is found in the incumbrance of the tracks with freight trains. The newest locomotives can attain a speed exceeding one hundred miles per hour, but they can never practically exceed sixty-two miles per hour, because of the freight trains and the great number of stations. Scherl would employ the present railway lines for freight exclusively, and would construct entirely new lines for passenger traffic. Economically, no objection can be made to the first part of this proposition, because the profits of our railways are derived from the freight traffic, while the passenger traffic scarcely pays for itself.

The new lines for passenger traffic would be of the single-rail system. They would be, for the most part, elevated, especially over cities, and would run in straight lines between the most important centers of population and commerce. These lines would connect with a system of "feeders," constructed in the same way, and connecting the main lines with smaller towns. A third system of lines would bring still smaller places into communication with the second, while the smallest and most remote hamlets would be connected with the general system by automobile stage routes.

The trains would be operated by electricity, and each would contain three cars. On the main lines a speed of 125 miles per hour could be obtained, and the trains would succeed each other at short intervals, half an hour perhaps, so that time-tables would not be required, but the passenger could start on his journey at any hour of the day or night. The cars as designed are much wider than those now in use, and are provided with every appliance for comfort. There is one class, as in America, and the trains have something of the character of hotels. The first car contains a lunch counter; the second car, a general room, resembling that of a hotel. In this car is a newspaper stand and an information bureau. The stations would be announced in advance in all the cars by large and easily legible signs, lighted by electricity, which would warn the traveler intending to leave at the next station, to make his way to the middle car. The rear car contains a fine dining-room, with a band of music. The train is also provided with special rooms for reading, writing, typewriting, and with bath-rooms and dressing-rooms, so that the traveler could leave the train ready for business or society. The introduction of the one-track system would diminish the initial cost and, in connection with the freedom from curves, would make possible the great speed mentioned above. Vibrations of the car would be prevented by the use of some modification of Schlick's gyroscope, which keeps vessels steady in very rough water. The main lines would cross the cities on high concrete towers, which would, if necessary, be situated inside the buildings. The buildings, however, need not be greatly depreciated, because the interior of the towers could be used for elevator shafts or stair wells. Each of the large cities would have one immense central station, from which the main lines would radiate in all directions, and the city lines would radiate parallel with them, from the same station. Connection would be made between the main and city lines at certain other points, by means of peculiarly constructed and operated elevators. The elevator car, containing the passengers intending to take the through train, would be raised to the through platform, just before that train's arrival. The middle car of the train would stop close to the elevator car.



RAILWAY VIADUCT THROUGH A CITY.



SINGLE-RAIL ELECTRIC RAILWAY.

CROSSING STATION OF CITY AND THROUGH LINES.

CENTRAL STATION IN A LARGE CITY.

THE MIDDLE CAR.

RAPID TRANSIT IN THE FUTURE.

and the passengers could be transferred between them in both directions in one minute or less. In this connection, Scheri appears to have forgotten that long stops at stations are made necessary, less by the transfer of persons than by that of baggage and postal matter. This system would reduce the time of transit between various European cities to between one-third and one-half of the time now occupied.—Translated for SCIENTIFIC AMERICAN SUPPLEMENT from Reclams Universum.

Correspondence.

THE MESSINA EARTHQUAKE AND THE EVENTS PRECEDING IT.

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

While there is an apparent correspondence through the whole range of subterranean phenomena and an interdependence between vulcanism and solar disturbances, the manifestations of the giant forces which bring such ruin and devastation in their train are sometimes so complicated that it is difficult to prove that all the seismic phenomena of a period are concurrent. The decade 1900-1910 has been a period of great seismic activity, and a more careful study of the events has been made than was ever possible before. With the opportunities thus afforded to group the occurrences of the great eruptions and sunspots, of solar flames and earthquakes, their correlation becomes plainer, and we begin to realize that none of those wonderful phenomena was an instance of individual action.

During this period the explosions of volcanoes and the grinding roar of earthquakes have been heard all over the globe, reaching a climax in 1907, when the whole world was in a state of unrest. From that time the eruptions have been fewer and fewer, though the impulses which cause the lands to tremble are still sending their waves vibrating through the crust of the earth. Comparing the records of this decade with those of the two previous ones, the same periodic variation appears, the sixth and seventh years being most fruitful in seismic disturbances, while the second year comes next in point of numbers; in each decade the same periodic variations occur, and they always correspond with the sunspot cycles. Nothing in all the realms of nature is more perplexing than these variations, but the periodicity is incontestable; the grouping of these events into a certain period or fixed part of a period seems to prove that there are laws which govern the movements in the complex systems of the earth and of the sun, and that however discordant may be their action, the tone is eventually restored and they become once more parts of a harmonious whole.

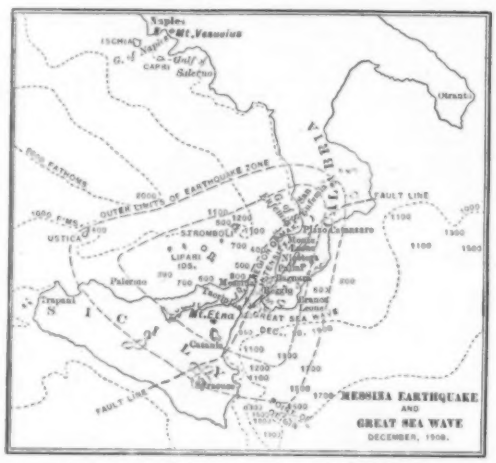
The two great centers of active vulcanism are Mauna Loa in the Pacific, at the center of the water continent, and Vesuvius in the Mediterranean, at the center of the land continent. Whenever a disturbance becomes pronounced on Loa or Kilauea, it is followed shortly by an eruption or an earthquake at some point in the Pacific Basin. In the Mediterranean the lines of weakness radiate from Vesuvius or its companion, Stromboli, toward Sicily and Algiers, Carthagena and Barcelona, the Riviera and Asia Minor, but there is a peculiarly intimate relation between Vesuvius and the Calabrian district. This is the more remarkable because there is no apparent connection with Mount Etna. The Etna quakes and those of Ischia on one side and of Santorin on the other side are invariably local and their tremors are only felt a short distance away, but the Calabrian quakes are always severe, and they even shake the Sicilian coast with great power. When the vent of Vesuvius closes entirely, there is danger of an earthquake in Calabria, and conversely an earthquake in Calabria is generally followed by an eruption on Stromboli or Vesuvius. The line of weakness which passes through this territory circles the Pacific Basin, extending through the mountain ranges on the western side of the American continent, through the West Indies, across the Atlantic by way of the Canaries, through Algiers, Tunis, Sicily, Calabria, Zante, Erzeroum, through the Caucasus into Central Asia. Along this line there have been earthquakes and eruptions every year during this decade, some of them being very severe, while the region on both sides of the Straits of Messina has been in a state of extreme instability, and the crust has been so weakened by successive shocks that it is particularly responsive to a sudden strain.

The year 1902 opened with an eruption on Kilauea, followed by an earthquake in Guatemala, eruptions of Pelée, Soufrière, and Mauna Loa, and earthquakes in the Caucasus, Calabria, the Azores, the Philippines, Central Asia, Turkestan, Spain, and Algiers. Then there was comparative quiet until 1905, when there was a severe earthquake in Calabria, whose destructive effects were felt from Catanzaro to Reggio. The loss of life was great, and the after-shocks continued for months, ending with the great eruption of Vesuvius in 1906. In this year were the earthquakes of San Francisco, Buguslof, Valparaiso, and the Solomon Islands.

The year 1907 began with an eruption on Mauna Loa on January 10th, followed in a few days by the Kingston earthquake and by others in Unalaska, the Mexican Plateau, the Fiji Islands, the Azores, Erzeroum, the Caucasus, and Central Asia. On October 17th there was a sudden cessation of the column of vapor from Vesuvius, and on October 24th a shock lasting seven seconds shook all the towns in Calabria between Branca Leone and Monte Leone; in all, 28 towns were badly damaged and 32 less seriously. On November 15th immense flames were noted shooting up from the sun, and on the 18th the towns about Reggio were severely shaken. Vesuvius became active on November 25th, but without an important eruption; at the same time, shocks occurred in Manila, Turkestan, and Spain, and a submarine volcano erupted near the Cape Verdes.

There was a cessation of activity in December, but in January, 1908, the earth waves were storming again. Reggio, Branca Leone, and the intervening towns were shaken. In February severe shocks were felt at Reggio, near Messina, with great sea waves in the Atlantic off Newfoundland. In March Mexico and Guatemala were shaken. In April there were shocks in the Congo region with great sea waves off Nantucket. In May there were shocks in Samoa and the Caucasus, Etna was active with great sea waves off Cape Horn. In June the Samoan volcanoes were active and there was a severe earthquake in China. In July there were shocks in California and Algeria, with brilliant sky glows and auroras. At this time there was a complete stoppage of seismic activity, but the giant forces were only gathering strength for another outburst.

On September 12th an immense sunspot was photo-



MAP OF THE MESSINA DISTRICT.

graphed, and the leaping pillars of the aurora shone in the northern sky for six hours. This ought to have been taken as a warning, but it did not attract much attention. Activity soon appeared along the line of weakness. On September 17th there was an earthquake at Guayaquil; September 20th, one at Hilo, and Kilauea became active; September 24th there was a shock at Argentina, and on the same day one at Acapulco with a great sea wave. October 20th, shocks at Manila; October 21st, shocks in Saxony, lasting for two months; November 2nd, a great volcano in southern Chili erupted with violence; Reggio and Branca Leone were shaken; December 10th there was a shock near Vancouver and Messina was shaken; December 13th, 14th, and 18th, great sea waves were felt in the Atlantic between Georgia and Newfoundland; December 17th a shock was felt in Guatemala; December 20th, in France and Kentucky; and on the 28th was the great earthquake at Messina and a mine explosion in West Virginia.

Following these, in January, 1909, shocks were felt in the Canaries, Algeria, Kentucky, Mexico, the ocean cable was broken 175 miles from Seattle, and on the same day there was a mine explosion in West Virginia, magnetic disturbances were noted in the Gulf of Mexico, minor shocks were felt in Smyrna and the Ionian Isles, and a severe one in Persia. In February there were earthquakes in France and in the Caucasus, and on the 16th, simultaneously in Hungary, Asia Minor, near Lisbon, at Symrna, St. Thomas, Porto Rico. Kilauea was active, and there was a serious coal mine disaster near Newcastle, England. In March there were earthquakes near Smyrna, in the Mexican Plateau, at Guayaquil, Buenos Aires, and the great volcanoes of Colima and Izalco were in eruption.

This recapitulation may seem tedious, but it is necessary to show that neither this earthquake nor any other of this period was an isolated phenomenon, and that the Messina earthquake was only a more serious manifestation of the movement of the earth waves which have been pulsing through the earth's crust since the sunspot of last September, and which reached the Straits of Messina when the surface on both sides was in a weakened condition owing to frequent shocks of the last three years. In this earthquake there were no foci, no epicenters; on the contrary, as the earth waves met with interference in the faults of the rock strata and in the alluvium of the coastal plains, their movement became excessively complicated, and it was the complex disturbance rather than any uplifting of the surface that produced the destructive effects. The rate of transmission of the waves was diminished by the interference, but the amplitude was increased, and the rhythm was so short and the oscillations followed each other so rapidly that there was no time for readjustments, and the waves had a trembling rather than a vibratory motion, which reduced the alluvial soil to a semi-liquid condition, so that it was easily set in motion. At the same time there was an additional complication in the formation of the great sea waves, of such rapid rate and such extreme amplitude, that they added enormously to the terror and to the destruction. The earth waves and the sea waves came simultaneously from the two nodal points, one in the Tyrrhenian Sea and the other in the Mediterranean, each of which is 85 miles distant from Messina, and their force was concentrated in the narrow part of the straits between Reggio and Peloro.

The city of Messina is situated at the extremity of a mountain spur on the coastal plain, which is of small extent and formed of alluvial soil. The plain is not over half a mile in width, and immediately back of it are ranges of hills, 500 feet high, running back to the mountain range, which is over 3,000 feet high, and the slope of the land extends about a mile into the straits, where the depth is 1,200 feet. The harbor of Messina is formed by a spit of low land which runs out into the straits a short distance and then curves to the northeast. The towns on the coast south of Messina are also on a narrow coastal plain, but the slope to seaward is more gradual. On the north coast the city of Palermo is apparently in as dangerous a position as Messina. The main fault line in Sicily extends through the plain of Catania, and nearly in a straight line from Catania to Reggio and Monte Leone in Calabria. The secondary fault lines in Calabria radiate to the curving coast and extend into the sea.

On the morning of December 28th an earth wave started at Ustica, the most westerly of the Lipari Isles, at 5:20 A. M. Palermo had a severe shock, and the cable to Lipari was broken 25 miles from Messina. Simultaneously, shocks were felt at Syracuse and Catania and nearly at the same moment in Messina. It is difficult to ascertain exactly at what moment they started on the Calabrian coast, but there seems to have been an appreciable interval. Their duration was longest at Messina and Reggio, at which places they lasted 23 seconds, and this was sufficient, at Messina, to disintegrate the alluvial soil, causing it to flow in different directions, depending on the shape of the underlying rocky slopes. The principal crevasse was parallel to the shore line, passing through the Cathedral and the Piazza Garibaldi, and along the Corso. From this line the sliding movement was downward toward the water, and as the crevasse was in some places five feet in width, the walls of the houses were evidently separated by that amount, with the natural result that the floors all fell down between the walls and all the water, sewer, and gas pipes were broken. There was a confused movement of the land of the spit, and the coal depot, drydocks, and citadel were all destroyed and the lighthouses at the point were thrown down. At other points on the Sicilian coast the damage was comparatively small, owing to the limited duration of the shocks, except at Cape Peloro at the entrance to the straits. On the Calabrian side at Reggio all the houses were thrown down by the shock, which extended as far as Monte Leone on the north and Branca Leone on the south.

Immediately following the passage of the earth waves along the fault lines, two great sea waves arose abreast of Catania and traveled up the straits, following each other closely along the deepest part. The water rose, forming the first wave, and then receded to the second wave. The waves passed through the straits, doing but little damage until they reached Messina, but on the Calabrian side they flooded the coast from Catanzaro on the south to San Eufemia on the north, doing most damage between Reggio and Pizzo. In the confusion which reigned everywhere it was impossible to make accurate estimates as to the height of the waves, but judging by the points reached on shore, they must have been 15 feet high, and it is more than probable that the wave passing up the straits was met by another from the north at the northern entrance of the straits, for in no other way can we account for the high wave at San Eufemia and for the direction of the waves inside the harbor of Messina.

Owing to the marked instability of this region, the

vibratory movements of elevation and depression caused stresses to be set up along the fault lines, and the effort of gravity to effect restitution has caused and will continue to cause after-shocks for at least a year.

It has been said that the cause of the earthquake was a sudden dislocation of a tectonic nature together with a sudden dropping of a large part of the ocean bed, but there were no results to support such a theory. On the contrary, the topography of the Straits of Messina has not been changed.

New Orleans, La. JOHN C. SOLEY,
Lieut. U. S. N. in charge of Branch Hydrographic Office.

SOLAR ACTIVITY AND TERRESTRIAL PHYSICS.

By A. NODON.

RECENT observations by Mémery recall attention to the indirect influence of solar spots and faculæ upon terrestrial phenomena. Some observers, including Oddone and Moreux, believe that the influence of the sun upon the earth is connected with the appearance of sunspots, with their passage over the central meridian, and with their area. Other observers, including Deslandres, Marchand, and Wolfer, attribute a preponderating influence to the passage of the faculæ, asserting that the facula is a more persistent phenomenon than the sunspot, which it both precedes and follows. However, if the facts are examined impartially, comparatively little importance can be attached either to the spots or to the faculæ. It seems probable, in fact, that the visible phenomena are only secondary results of invisible processes which are the prime causes of solar activity.

The spots and faculæ are probably produced by profound perturbations of the photosphere, which extend as far as the corona. Most frequently the two phenomena are simultaneous, and the active regions seem to be more persistent when this is the case. Mémery finds that a solar region containing faculæ alone without spots, seldom persists during several revolutions. Often also the solar activity is manifested rather during the decrease of spots and faculæ than during their passage over the meridian. These facts may find a satisfactory explanation in the passage of curved coronal rays.

The earthquake at San Francisco in April, 1906; the eruption of Mont Pelée in May, 1902; the earthquake at Nice in February, 1887; the eruption of Krakatoa in August, 1883; the earthquake at Ischia in July, 1883, etc., coincided with decreasing phases of solar activity. It must also be remembered that the epochs of most frequent earthquakes, such as the present year, correspond to the minimum epochs of the eleven-year period of solar activity; that is to say, to the epochs in which the spots, faculæ, protuberances, and coronal rays are decreasing.

Another interesting observation of Mémery concerns the annual periodicity in the decrease of spots and faculæ. For example, he finds a decrease just before the 29th of December, during several years of observation, and a second decrease between the 15th and 20th of April. These periods appear to correspond to an abnormal lowering of the temperature and to an annual frequency of earthquakes.

It would be interesting to repeat these observations, in order to discover, if possible, some relation between solar activity and the relative positions of the earth and the planets. In short, from all the foregoing facts it appears evident that studies of solar activity can only be pursued in a really methodical and useful manner if especial attention is paid to the study of the phenomena which cause this activity. The observation of the optical and thermal phenomena of the solar surface should very probably be relegated to the second place in the study.

The electrical influence of the sun, the reality of which several physicists are endeavoring to demonstrate by means of systematic observations, is manifested, very probably, in a great variety of forms: static, magnetic, electro-magnetic, ionization, cathode and anode rays, Roentgen rays, Hertzian waves, etc. It seems very probable that the electrical action of the sun will be still more clearly understood after investigation of the relation between terrestrial phenomena and the meridian passages of solar electrical activity. For example, a very desirable work in an observatory would consist in comparing daily the electrical state of the sun and of the earth with:

First. The optical and thermal state of the solar surface.

Second. The general atmospheric conditions in Europe.

Third. The general atmospheric conditions in France (or other country of observation).

Fourth. The variations of the principal meteorological elements of the vicinity of the observatory.

Fifth. All violent storms, cyclones, earthquakes, volcanic eruptions, etc., occurring throughout the earth on that day.

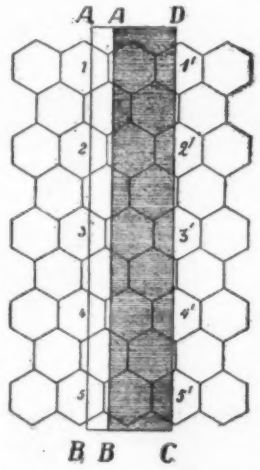
By employing a graphical method of recording the variations of these different phenomena, it would be possible to trace curves which would clearly show their mutual relations. The electrical charge of the surface of the earth appears to be subject to variations which are directly connected with variations in the meridian passages of the electric activity of the sun. The measurement of the terrestrial charge and the solar charge, by instruments placed in a number of observatories distributed over the earth, would probably furnish valuable information concerning this important question. The study of electro-magnetic variations at the sea level and at great altitudes would form a useful complement to the preceding observations. The observation of terrestrial magnetic disturbances is connected with the same question.

In short, it appears to be proved by observed facts that the sun furnishes the primordial cause of all terrestrial phenomena, and that this cause is not connected directly with the light and heat of the solar surface, but is most probably electrical. Hence it appears logical to conduct our investigations in accordance with this view, in order to solve as quickly as possible the important problem of the influence of the sun on the earth.—Cosmos.

THE SMALLEST PERCEPTIBLE MOVEMENT.

By DR. ADOLF BASLER.

IT is obvious that there must be a limit of magnitude below which movement is imperceptible. In order to determine this limit, a narrow strip of white paper was attached to the short arm of a lever and a millimeter scale was placed behind the end of the long arm. The ratio between the arms being known, it was possible, by means of this arrangement, to move the strip of paper through a very small and accurately measured interval.



RETINAL ELEMENTS AND MOVING IMAGE.

It was found that persons with normal acuteness of vision, looking at the strip of paper from a distance of 12 inches, could detect with certainty a movement of 1/800 inch, corresponding to a visual angle of about 20 seconds, and to a displacement of the image on the retina by 1/17000 inch. Several persons could detect a movement of the paper as small as 1/1200 inch.

The smallness of these movements will be better appreciated when it is recalled that two points 1/800 or 1/1200 inch apart cannot be distinguished as two points by the naked eye. Hence the eye can perceive a movement smaller than the interval between two points that appear as one.

This paradox may be explained as follows: The sensitive layer of the retina is a mosaic of separate sensitive elements. Two points cannot be distinguished as two unless their vertical images are separated by at least one element, which is not affected by either. This is the case with the points corresponding to the images 1 and 1' in the diagram. On the other hand, the movement of a luminous body is perceived as soon as the stimulus affects a certain number of new elements, as in the movement of the edge of the image (*ABCD*) of the strip of paper, from *AB* to *CD*, the average displacement required being much less than the diameter of a retinal element. It is a remarkable fact that these very small movements were greatly overestimated by all the observers.

In another series of experiments, in which the distance between the strip of paper and the eye was increased to two yards, the minimum perceptible movement was found to be proportionally increased, so that the required angular displacement (20 seconds) and retinal displacement (1/17000 inch) remained the same as before.

When the eye was fixed, not on the strip of paper, but on a fixed point beside it, the minimum perceptible movement was found to increase in proportion to the distance of the fixed mark from the strip.

In another series of experiments the room was darkened and a slit illuminated from behind, was substituted for the white paper. In these conditions the smallest movement perceived was about four times as great as the minimum perceptible displacement of the white paper. In this case, also, it was found, by directing the eye to marks at various distances from the slit, that the sensitiveness of the retina to movement diminishes as the distance of the part of the retina employed from the central area of most distinct vision increases.—Umschau.

FOSSIL MAN.

PROF. MARCELLIN BOULE, of the Paris Natural History Museum, has lately given some additional details about the fossil human remains which were found in France at Chapelle-aux-Saints. We have mentioned the characteristics of the skull, and will now present some of the leading features of the skeleton. Prof. Boule succeeded in collecting a sufficient number of the bones in order to reconstitute a great part of the skeleton of the trunk and the members. In general, the *ensemble* of the skeleton, which is composed of relatively short and thick bones, with powerful muscular insertions, has very robust characteristics. Its various parts show a striking resemblance with the corresponding parts of the Neanderthal and Spy skeletons, which confirms the unity and likeness of the group. He has 18 vertebræ, some whole and others broken. They are remarkable for their shortness, especially at the neck. The individual must have been of small stature and have a remarkably short neck. We find short and thick ribs which are not much flattened in section. The two shoulder blades are almost complete, and the left one is much weaker than the right. The bones of the arms indicate a strong muscle. He possesses a few remains of the hand, and finds that they show some peculiar characteristics, among others a much greater facility of movement for the hand in all directions than for the ordinary man. None of the large monkeys appear to show this quality in such a pronounced degree. Regarding the pelvic bones, of which he has good remains, the iliac bones are noticed for their width, which is an essentially human feature, and also for their shallowness, this being on the contrary a simian characteristic. Their thickness is considerable. From the leg bones, it appears that the lower members were somewhat curved, as we find in the anthropoids. The heel bone is of unusual size and this is one of the most interesting points. On the whole, Prof. Boule concludes from his examination of the remains that from the appearance of the skeleton of the trunk and members, as well as from that of the skull which we have already mentioned, the fossil belongs clearly to the human group. However, it presents a mixture of features. Some of these are found only in the lowest orders of the present human race, while others are especially observed in the anthropoids.

Lastly, there are other features which are particular to the present specimen.

A SWEDISH RADIUM ENTERPRISE.

THE London Electrical Review announces that the preliminary notice has been locally registered for the formation of the Culm Company, which proposes, according to various inventions of Dr. G. Hellsing, to win uranium and radium from the mineral culm and other raw materials, and to dispose of patents and licenses. The minimum share capital has been fixed at 700,000 crowns and the maximum at 2,100,000 crowns.

The promoters of the company are Profs. J. G. Andersson, Svante A. Arrhenius and Sten, A. Hj. Sjorgen, Dr. G. H. Hellsing, and C. U. Waern, the names being said to be apparently a guarantee that the scheme rests upon a scientific basis. Prof. Andersson is the manager of the state authority known as Sweden's geological investigation; Prof. Arrhenius is the celebrated physicist and Nobel prize winner, and Prof. Sjorgen is the superintendent of the government mineralogical collections and successor to the discoverer of the North-Eastern passage. It appears that Prof. Nordenskjold, Dr. Hellsing, and other founders have for several years past investigated the mineral culm, which is a kind of impure pit coal existing in the Alaun schist, for the winning of uranium and oils. After it had been discovered abroad that most minerals embodying uranium also contain radium, the latter has likewise been discovered in culm, which exists in an inexhaustible quantity in the Swedish province of Vastergotland.

The promoters of the company have assured themselves of considerable fields in this province, one alone containing 100,000 tons of culm. As a result of previous experiments it has been found, it is stated, that 1 ton yields 4 millimeters of radium bromide, a combination which is said to be admirable for the market.

Denmark no longer imports her supplies of cement from the United Kingdom, but exports cement abroad in considerable quantities.

ORNAMENTAL FISHES.

SUGGESTIONS FOR THE AQUARIUM.

BY BERTHOLD KOERTING.

EVERYONE remembers the old-fashioned glass globe in which a few goldfishes led a wretched existence. The water was supposed to be changed and a pinch of ants' eggs given every two or three days. Even the patient and long-enduring goldfish did not usually long survive this treatment. The goldfish globe is now almost obsolete. In its place is an aquarium adapted to the conditions of piscine life, which is an ornament to any room and requires a minimum of care. In every large city are shops devoted to the supply of everything needed for the cultivation of fishes: Aquaria of all sizes, suitable earth and sand for strewing on the bottom, pretty aquatic plants, and fishes of every kind from all parts of the world. The plants are not only ornamental, but they keep the water fresh and clear, and furnish a continual supply of oxygen for the fishes to breathe. For the proper growth of the plants, it is necessary to give the aquarium abundant light. Then it is never necessary to change the water, and both the plants and the fishes flourish exceedingly. It is true that the glass sides of the aquarium soon become covered with green algæ, which make it difficult to see the inhabitants, but there is a simple remedy for this. A few water snails placed in the aquarium will quickly devour the algæ and keep the panes clean. The snails themselves are very interesting creatures. They soon begin to lay, and produce thousands of little snails, which are still more interesting. Nothing remains to be done except occasionally to remove with a small siphon any dirt that has collected in corners, to supply the loss of water caused by evaporation, and to feed the fishes daily. Beyond this the less that is done, the better.

The Chinese have bred and cultivated ornamental fishes for many centuries. Goldfish were introduced into Europe from China in the seventeenth century,

FIG. 2.—MACROPOD.

when a few of these curious creatures were presented to the Marquise de Pompadour. The Chinese developed the golden variety from a fish which is brownish gray in its natural state. They did not stop with this result, but in their love for strange and curious forms they have succeeded in producing the most grotesque variations. One of these is the long-tailed goldfish (Fig. 1a), in which all the fins are greatly increased in length and breadth and the caudal fin is doubled. The effect of this long trailing mass of fins is enhanced by contrast with the short and almost spherical body. This combination of elements makes motion almost

FIG. 3.—A PAIR OF MACROPODS.

impossible, yet a large aquarium filled with fine examples of this fish presents a wonderful spectacle. Specimens with particularly long and pliant fins command prices exceeding $25. Equally costly is the telescope fish (Fig. 1b), which possesses very large fins and curious protruding eyes set upon high ridges. It would hardly be suspected that the slender and graceful goldfish is the ancestor of these grotesque creatures. Both of these varieties are rather dull and stupid, and possess little attraction except their gorgeous coloring. Very different are the macropods (Fig. 2). These also come from China, where they have been bred in captivity so long that zoologists are not agreed whether they form an artificial variety or a natural species. They have not yet been found in the wild state. Their lively dispositions and brilliant colors make them among the most interesting inhabi-

FIG. 1.—TWO REMARKABLE VARIETIES OF GOLDFISH.

tants of the aquarium. They soon make themselves at home in a very small aquarium, become tame, take food from the hand, and even leap for it when it is held an inch or two above the water. With the first warm days of spring they begin to display bright red and blue colors, and delight the observer by their pretty love play. The male spreads his fins and displays his magnificence like a peacock. His mate at first turns away in disdain, but, on being pursued, deigns to return her wooer's attentions, and both float motionless side by side, with brightened colors, widely extended fins, and quivering bodies. After this play has been repeated, with variations, many times, the

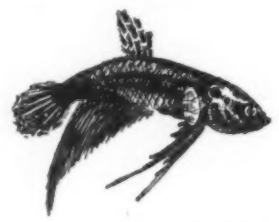


FIG. 4.—FIGHTING FISH.

male builds a floating nest entirely of foam. The wooing continually becomes more ardent, and the two fishes actually embrace beneath the nest (Fig. 3).

Finally tiny yellow eggs appear among the pearly bubbles of the nest. The female is then driven away by her mate. The care of the eggs falls entirely to the male parent, who among other things has to defend the brood from the attacks of the cannibal mother. Almost black with excitement he stands guard under the nest, incessantly rearranging the eggs and removing all newly-formed air bubbles, leaving his post only for an instant at a time to repel intruders. The valiant defender of his offspring has even been known to leap into the face of an observer bending over the aquarium. In three or four days the eggs hatch into tiny fry, which are tenderly cared for by the father, who continually catches stragglers and carries them back to the nest in his mouth. He also holds the weaker ones for a short time in his mouth and returns them to the nest covered with foam. But his paternal affection only lasts about a week, and he then deserts the family and goes off to found a new one. A pair of macropods in my possession produced seven broods last summer. This fish is sometimes called, from its beauty, the Fish of Paradise, but it is excelled in splendor by its small kinsman, the fighting fish (Fig. 4). This small living jewel is a native of Siam, the land of cock fighting, where this pugnacious little fish has long been bred with great care for fighting purposes. Siamese sportsmen are able to estimate the chances of victory of their champions from their size, the dimensions of their fins, the liveliness of their movements, and so on, as accurately as horsemen can predict the success of a thoroughbred. Large sums are paid for good fighters and good breeders, and great wagers are laid on the combats, which are watched with the greatest attention. The magnificence of color display by the jealous and pugnacious male fishes when fighting is indescribable. Their fins and scales appear to be set with rubies, turquoises, and opals, their gill covers are expanded like shields, their fins outspread, their bodies curved for the forward spring. Slowly, with quivering fins, they circle round each other, each waiting for the slightest exposure on the part of his opponent which would make it possible to inflict a bite. At last one combatant flees with tattered fins, pursued by the victor, who in the glory of his triumph appears in greater splendor than ever, while the colors of his vanquished adversary gradually fade. The coloring of the females is comparatively sober, a dull yellow-brown with a wide dark longtitudinal stripe. The females are smaller than the males, and have smaller fins in proportion to the size of their bodies. These fighting fish also breed in the aquarium. Their courting is similar to that of the macropods, except that the male is not quite so tender and affectionate, but more violent and impetuous. In spite of the pugnacity of the males these fishes may be kept safely with other species, to which they pay little attention. I have kept a pair in a very small aquarium with a few small macropods and guramis.

Several species of gurami (Fig. 5) have been introduced into Europe in recent years. They are very pretty fishes, distinguished by the nacreous sheen of their scales and the transformation of the ventral fin into long streamers. The illustration shows a pair of the best-known species, with the female on the left and the more brightly-colored male on the right. The beautiful blue color of the anal fin, the bright red band which surrounds it, the red spots on the caudal and dorsal fins, and the transverse stripes, gleaming in all the colors of mother of pearl, make these fishes worthy companions of those already described. In the aquarium they appear at first shy, and withdraw

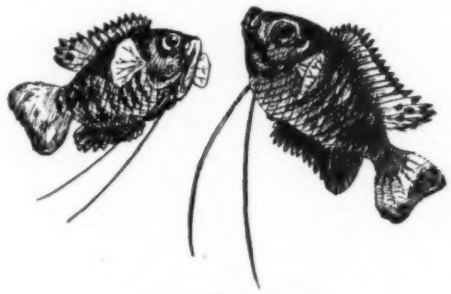


FIG. 5.—GURAMIS.

to the darkest corners and densest growth of plants, but they soon acquire confidence and move with vivacity through the clear water, extending their long streamers forward like feelers, now pressing them together, now separating them. They are often seen swimming up and down along the grass-like leaves of the aquatic plants and removing the small algæ with which these are covered. Like all vegetarian fishes, they are very peaceful, so that they can be kept with fishes of any other species. Guramis, fighting fishes,

FIG. 6.—PERCH.

and macropods all belong to the peculiar family of labyrinth fishes, so called from an organ of respiration in the throat, which consists of greatly branched canals and enables the fish to breathe directly air caught in mouthfuls above the surface, besides breathing through gills. This capacity enables them to live in water which contains very little air, and makes them remarkably long lived and resistant aquarium fishes.

Another family of fighters, many species of which

are sold as ornamental fishes, is the perch family. Two species, the slender pipe perch and the ruff, are natives of Europe. Most of the other species, including the rapacious trout perch (Fig. 6a), the black perch, the beautiful sunfish, the stone perch (Fig. 6b), the moonfish, etc., come from America. Especially beautiful are the steel-blue calico perch with its high sail-like fins (Fig. 6c) and the diamond perch, whose bright yellow coat with dark bands and red fins look as if thickly set with brilliant gems. Most striking of all, however, is the disk perch (Fig. 7), which always carries its fins vertically, as if challenging admiration. All these perches are very rapacious, courageous, and pugnacious fellows, with whom fighting is a daily occupation. A large aquarium filled

FIG. 7.—DISK PERCH.

with a variety of perches affords lively entertainment. Soon every inmate has selected his favorite spot, which he defends valiantly against all intruders, and a series of duels soon establishes an order of rank, so that each one knows which of his companions he can vanquish and which it is prudent to avoid. Always suspicious, observing everything with their large and brightly-colored eyes, they swim past each other with their spiked fins extended, always prepared for attack or defense. When they are fed with bits of raw meat the strongest assert their right to eat first, leaving the remnants for their weaker brothers. Often a violent combat occurs for the possession of a morsel. Occasionally a fish which has captured a piece of meat which it cannot immediately devour is compelled to put to flight, followed by greedy rivals, but no perch will touch a piece of meat which falls to the bottom of the tank. The despised morsel would lie indefinitely on the bottom and pollute the water if it were not for the presence of a few other fishes which, although also creatures of prey, are not quite as fastidious as the perches, but diligently root in the mud for food. These are the catfish, known as bullheads (Fig. 8), which have long worm-like mouth feelers, which compensate for the deficiency of their sight. The sense of smell is also supposed to aid them in their search for food. They are extremely greedy and voracious, and lash their tails fiercely as they struggle for the possession of a morsel. During the day they usually lie sluggishly in sheltered parts on the bottom, but at feeding time, which they appear to divine, they come from their hiding places, to which they soon return, full fed and rotund. In the evening, by artificial light, they may be seen incessantly swimming up and down the sides of the aquarium. A similar behavior is exhibited by their near relative, the singular long-horned catfish shown in Fig. 9. With these fishes may be kept young specimens of the North Sea flounders (Fig. 10), which can be gradually accustomed to fresh water. Their rapacity, peculiar behavior, and singular method of swimming make them exceedingly interesting objects

FIG. 8.—DWARF BULLHEADS.

of study. Finally, this band of robbers may be completed by adding a few young eels.

Fiercer than all these is a little European fish, the stickleback (Fig. 11a), which is so savage that it cannot be kept with fishes of any other species. But the actions of these little fighters, their shrewdness and vivacity, are so attractive that they deserve an aquarium for themselves. When they have become accustomed to their home, they are easily induced to breed. In the pairing season the throat of the male becomes blood red, and he soons begins to build a globular nest of bits of leaves and roots, in which the female lays her eggs. All day long the male remains before the door of the nest, untiringly moving his pectoral fins and forcing a current of water over the eggs. Wo to the fish who comes near! He is immediately attacked and repulsed by the guardian of the nest. In the densest tangle of plants in the corner of the aquarium, all the other inmates take refuge. After a few days the male stickleback removes the upper part of the nest, leaving only a flat saucer-shaped portion, in which a sharp eye can detect a moving throng of tiny fishes over which the father, redder and more excited than ever, keeps vigilant guard, allowing none of the little ones to escape and no other fish to approach. A small relative, the dwarf stickleback (Fig. 11b), has the same habits.

It would exceed the limits of this sketch to mention all the interesting fishes which can be kept in the aquarium, and which exhibit remarkable habits of life and methods of caring for their young. For example, the pretty little bitterling leaves to the fresh-water mussel the care of hatching its eggs and tending its young until they become large enough to take care of themselves. In conclusion may be mentioned the smallest and most delicate of all aquarium fishes, the toothed carp, of which there are several species, all very lively and rapid of movement. These also breed easily in a small aquarium, and almost alone of fishes bring forth their young alive. Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Prometheus.

THE COMMERCIAL POSSIBILITIES OF THE DUGONG.

EFFORTS are now being made to turn the dugong, more popularly known as the "sea cow," to commercial utility. The waters of Australia constitute the habitat of this unique animal. It is particularly plentiful off the coasts of Queensland. The creature is probably one of the most curious of the mammalian species, and has been the object of much mystery, having undoubtedly been the origin of the remarkable tales concerning the mermaid.

FIG. 9.—LONG-HORNED CATFISH.

The dugong, when fully grown, frequently attains a length of some 9 feet by over 30 inches across the broadest part of its back, and turns the scale at over 1,000 pounds. Its head is peculiar, being a cross between that of a fish and a pig. Thick and strong bristle-like hairs inclose its nose, which it uses for tearing the long grass upon which it feeds. Its tongue is long and rough, and the teeth formidable. The upper jaw is also equipped on either side with a white ivory tusk, which in the case of the male grows to a length of some 6 inches by about 1 inch in diameter, but in the female is much smaller. A short distance behind the head are two short, thick flippers. In the case of the female the space between these limbs on the under side is occupied by a breast, very similar to that of a woman, and which no doubt fostered the identity of this quaint fish with the mermaid. During the time the young are of tender age they cling round this part of the body, being shielded by the flippers, which the mother also uses to guard her offspring against molestation. From this part the body tapers sharply toward the tail, which resembles that of the whale, is very powerful and by means of which the fish can propel itself through the water at considerable speed.

The skin is exceptionally hard and thick, being an inch or so in thickness on the top of the back, of a dark slaty color, and densely covered with short white bristles somewhat after the manner of the pig. Invariably these bristles are found to afford an ideal anchorage for barnacles and similar marine growths. On the under portion of the body the skin is much thinner, though equally tough and whitish in color.

Owing to its strength and texture, this hide can be fashioned into a very serviceable leather, but it is utilized chiefly for its oil, which is in great demand, the average price being about $2.50 per gallon. This is extracted by cutting up the fish and submitting the flesh to a prolonged boiling. Certain portions of the flesh are also stated to be edible, "dugong bacon," as it is called, finding a ready market because of its excellent taste and nutritious qualities. The selected portions are cut out, salted, and smoked in the usual manner. Its chief claim is as a dietetic for consumptives, since it constitutes an excellent substitute for cod-liver oil, and is more pleasant to the palate. The tusks are also of value, as they are of a magnificent grade of ivory.

The necessary plant to exploit commercially this quarry is somewhat heavy in first cost. The animal is trapped by means of a net, which has to be of substantial construction to withstand the fierce struggles of the fish to release itself from its meshes. A good dugong net will cost something like $200, measures some 400 feet in length by about 10 feet wide, fashioned of ½-inch rope with a mesh of about 2 feet, and strung top and bottom upon a thick, heavy rope for hauling in. In addition to this, a battery of boilers must be maintained on shore for extracting the oil, as well as facilities for curing the bacon, comprising brine tanks and smoking huts, as well as a fleet of fishing boats.

FIG. 10.—FLOUNDER.

The feeding ground of the dugong can be easily ascertained. Its favorable haunts are close inland on the mud banks, where the dugong grass which constitutes its food grows luxuriantly. It is very gregarious, usually traveling in small shoals of a dozen or so. They frequent their feeding ground all the year round, but are sometimes observable at certain spots in greater numbers than at others. The dugong fisher sets off on his expedition late in the afternoon, after its whereabouts have been found—an easy matter, as, like the whale, it must come to the surface every few minutes to breathe, and its peculiar snout can be readily detected above the water. Even in the darkest night the fact that a dugong has come up to blow is very evident, and as it is known that the creature very rarely travels singly, the fisher at once sets his net in proximity to the spot. The landward end of the net is cast off about 200 feet from the shore and is paid out seaward, being held firmly in position by heavy anchors. At intervals the net is provided with large bungs similar to those used in ordinary fishing work, to betray the existence of the net, but these are supplemented by a large, empty plugged drum, acting as a float attached to the center of the net, together with a heavy balk of timber at either end. The net set, the fisherman returns to shore, confident that by morning he will have trapped one or more of the fish. It is in coming up to breathe that the dugong fouls the net, and at once makes frantic efforts to free itself, which result only in its becoming more firmly enveloped in the toils. Eventually it is drowned. When the fisherman returns in the morning, the presence of a white, upturned carcass standing well above the water level instantly betokens that his expedition has proved successful. The net is hauled in and the drowned quarry hauled ashore, where the oil extracting, skinning, salting, and curing are at once proceeded with. The comparative abundance of the fish and the great yield that is obtained of marketable products render the fishery remunerative, and established upon a commercial scale it should prove a profitable industry.

Horn Waste Mass.—The horn chips are laid in a fluid consisting of a cold saturated solution of boracic acid in water and a cold saturated solution of arsenic

FIG. 11.—STICKLEBACKS.

acid in dilute hydrochloric acid (spec. grav. 1). After working for a time, the mass is heated in a water bath for a short period to about 140 deg. F. The horn substance is then transferred to closed iron molds, which, by means of a suitable heating arrangement, are heated to about 248 deg. F., and by means of a piston working in the mold, subjected to heavy pressure, until all the fluid is removed. When the mass, thus pressed, has been allowed to cool, the horn chips will be found transformed into a solid mass, which can be worked like the ordinary horn substance.

CANNING AND PRESERVING FRUIT.*

HINTS FOR THE HOUSEWIFE.

BY MARIA PARLOA.

The common fruits, because of their low nutritive value, are not, as a rule, estimated at their real worth as food. Fruit has great dietetic value and should be used generously and wisely, both fresh and cooked. Fruits supply a variety of flavors, sugar, acids, and a necessary waste or bulky material for aiding in intestinal movement. They are generally rich in potash and soda salts and other minerals. Most fresh fruits are cooling and refreshing. The vegetable acids have a solvent power on the nutrients and are an aid to digestion when not taken in excess.

Fruit and fruit juices keep the blood in healthy condition when the supply of fresh meat, fish, and vegetables is limited and salt or smoked meats constitute the chief elements of diet. Fresh fruit is generally more appetizing and refreshing than cooked. For this reason it is often eaten in too large quantities, and frequently when underripe or overripe; but when of good quality and eaten in moderate quantities it promotes healthy intestinal action and rarely hurts anyone.

If eaten immoderately, uncooked fruit is apt to induce intestinal disturbances. If eaten unripe, it often causes stomach and intestinal irritation; overripe, it has a tendency to ferment in the alimentary canal. Cooking changes the character and flavor of fruit, and while the product is not so cooling and refreshing as in the raw state, it can, as a rule, be eaten with less danger of causing stomach or intestinal trouble. If sugar be added to the cooked fruit, the nutritive value will be increased. A large quantity of sugar spoils the flavor of the fruit and is likely to make it less easily digested.

Nowhere is there greater need of a generous supply of fruit than on the farm, where the diet is apt to be restricted in variety because of the distance from markets. Every farmer should raise a generous supply of the kinds of fruit that can be grown in his locality. Wives and daughters on the farms should find pleasure in serving these fruits in the most healthful and tempting form. There are a large number of simple, dainty desserts that can be prepared with fruit and without much labor. Such desserts should leave the pie as an occasional luxury instead of allowing it to be considered a daily necessity.

In the season when each kind of fruit is plentiful and at its best a generous supply should be canned for the season when both fruit and fresh vegetables are scarce. A great deal of the fruit should be canned with little or no sugar, that it may be as nearly as possible in the condition of fresh fruit. This is the best condition for cooking purposes. A supply of glass jars does cost something, but that item of expense should be charged to future years, as with proper care the breaking of a jar need be a rare occurrence. If there be an abundance of grapes and small, juicy fruits, plenty of juice should be canned or bottled for refreshing drinks throughout the year. Remember that the fruit and juice are not luxuries, but an addition to the dietary that will mean better health for the members of the family and greater economy in the cost of the table.

FRESH AND PRESERVED FRUIT FOR THE MARKET.

If the supply of fruit is greater than the family needs, it may be made a source of income by sending the fresh fruit to the market, if there is one near enough, or by preserving, canning, and making jelly for sale. To make such an enterprise a success the fruit and work must be first class. There is magic in the word "homemade," when the product appeals to the eye and the palate; but many careless and incompetent people have found to their sorrow that this word has not magic enough to float inferior goods on the market. As a rule, large canning and preserving establishments are clean and have the best appliances, and they employ chemists and skilled labor. The home product must be very good to compete with the attractive goods that are sent out from such establishments. Yet for first-class homemade products there is a market in all large cities. All first-class grocers have customers who purchase such goods.

To secure a market get the names of several first-class grocers in some of the large towns. Write to them asking if they would be willing to try a sample of your goods. If the answer is favorable, send samples of the articles you wish to sell. In the box with the fruit inclose a list of the articles sent and the price. Write your name and address clearly. Mail a note and a duplicate list at the time you send the box.

Fixing the price of the goods is important. Make it high enough to cover all expenses and give you a fair return for your labor. The expenses will be the fruit, sugar, fuel, jars, glasses, boxes, packing material, wear and tear of utensils, etc., transportation, and commission. The commission will probably be 20 per cent of the selling price. It may be that a merchant will find that your prices are too high or too low for his trade, or he may wish to purchase the goods outright. In any case it is essential that you estimate the full cost of the product and the value that you place on your labor. You will then be in a position to decide if the prices offered will compensate you for the labor and expense. Do not be tempted, for the sake of a little money, to deprive your family of the fruit necessary to health and pleasure.

Packing and Shipping.

Each jar or jelly glass must be wrapped in several thicknesses of soft paper (newspapers will answer). Make pads of excelsior or hay by spreading a thick layer between the folds of newspapers. Line the bottom and sides of the box with these pads. Pack the fruit in the padded box. Fill all the spaces between the jars with the packing material. If the box is deep and a second layer of fruit is to go in, put thick pasteboard or thin boards over the first layer and set the wrapped jars on this. Fill all the spaces and cover the top with the packing material. Nail on the cover and mark clearly: Glass. This side up.

The great secret in packing is to fill every particle of space so that nothing can move.

PRINCIPLES OF CANNING AND PRESERVING.

In the preservation of foods by canning, preserving, etc., the most essential things in the processes are the sterilization of the food and all the utensils and the sealing of the sterilized food to exclude all germs.

Bacteria, Yeasts, and Fermentation.

Over one hundred years ago François Appert was the first to make practical application of the method of preserving food by putting it in cans or bottles, which he hermetically sealed. He then put the full bottles or cans in water and boiled them for more or less time, depending upon the kinds of food.

In Appert's time and, indeed, until recent years it was generally thought that the oxygen of the air caused the decomposition of food. Appert's theory was that the things essential to the preservation of food in this manner were the exclusion of air and the application of gentle heat, as in the water bath, which caused a fusion of the principal constituents and ferments in such a manner that the power of the ferments was destroyed.

The investigations of scientists, particularly of Pasteur, have shown that it is not the oxygen of the air which causes fermentation and putrefaction, but bacteria and other microscopic organisms.

Appert's theory as to the cause of the spoiling of food was incorrect, but his method of preserving it by sealing and cooking was correct, and the world owes him a debt of gratitude.

In their investigations scientists have found that if food is perfectly sterilized and the opening of the jar or bottle plugged with sterilized cotton, food will not ferment, for the bacteria and yeasts to which such changes are due cannot pass through the cotton. This method cannot be conveniently followed with large jars.

Bacteria and yeasts exist in the air, in the soil, and on all vegetable and animal substances, and even in the living body, but although of such universal occurrence, the true knowledge of their nature and economic importance has only been gained during the last forty years.

There are a great many kinds of these micro-organisms. Some do great harm, but it is thought that the greater part of them are beneficial rather than injurious.

Bacteria are one-celled and so small they can only be seen by aid of a microscope. The process of reproduction is simple and rapid. The bacterium becomes constricted, divides, and finally there are two cells instead of one. Under favorable conditions each cell divides, and so rapid is the work that it has been estimated that one bacterium may give rise, within twenty-four hours, to seventeen millions of similar organisms. The favorable conditions for growth are moisture, warmth, and proper food.

Yeasts, which are also one-celled organisms, grow less rapidly. A bud develops, breaks off, and forms a new yeast plant. Some yeasts and some kinds of bacteria produce spores. Spores, like the dried seeds of plants, may retain their vitality for a long time, even when exposed to conditions which kill the parent organism.

Yeasts and nearly all bacteria require oxygen, but there are species of the latter that seem to grow equally well without it, so that the exclusion of air, which, of course, contains oxygen, is not always a protection, if one of the anaerobic bacteria, as the kinds are called which do not require oxygen, is sealed in the can.

Spoiling of food is caused by the development of bacteria or yeasts. Certain chemical changes are produced as shown by gases, odors, and flavors.

Bacteria grow luxuriantly in foods containing a good deal of nitrogenous material, if warmth and moisture are present. Among foods rich in nitrogenous substances are all kinds of meat, fish, eggs, peas, beans, lentils, milk, etc. These foods are difficult to preserve on account of the omnipresent bacteria. This is seen in warm, muggy weather, when fresh meat, fish, soups, milk, etc., spoil quickly. Bacteria do not develop in substances containing a large percentage of sugar, but they grow rapidly in a suitable wet substance which contains a small percentage of sugar. Yeasts grow very readily in dilute solutions containing sugars in addition to some nitrogenous and mineral matters. Fruits are usually slightly acid and in general do not support bacterial growth, and so it comes about that canned fruits are more commonly fermented by yeasts than by bacteria.

Some vegetable foods have so much acid and so little nitrogenous substance that very few bacteria or yeasts attack them. Lemons, cranberries, and rhubarb belong to this class.

Temperature is an important factor in the growth of bacteria and yeasts. There are many kinds of these organisms, and each kind grows best at a certain temperature, some at a very low one, and others at one as high as 125 deg. F., or more. However, most kinds of bacteria are destroyed if exposed for ten or fifteen minutes to the temperature of boiling water (212 deg. F.); but, if the bacteria are spore producers, cooking must be continued for an hour or more to insure their complete destruction. Generally speaking, in order to kill the spores the temperature must be higher than that of boiling water, or the article to be preserved must be cooked for about two hours at a temperature of 212 deg. F., or a shorter time at a higher temperature under pressure. Yeasts and their spores are, however, more easily destroyed by heat than bacteria spores. Hence, fruits containing little nitrogenous material are more easily protected from fermentation than nitrogenous foods in which in general fermentation is caused by bacteria. Of course, it is not possible to know what kinds of organisms are in the food one is about to can or bottle; but we do know that most fruits are not favorable to the growth of bacteria, and, as a rule, the yeasts which grow in fruits and fruit juice can be destroyed by cooking ten or fifteen minutes at a temperature of 212 deg. F. If no living organisms are left, and the sterilization of all appliances has been thorough, there is no reason why the fruit, if properly sealed, should not keep, with but slight change of texture or flavor, for a year or longer, although canned fruits undergo gradual change and deterioration even under the most favorable conditions.

When fruit is preserved with a large amount of sugar (a pound of sugar to a pound of fruit) it does not need to be hermetically sealed to protect it from bacteria and yeasts, because the thick, sugary syrup formed is not favorable to their growth. However, the self-sealing jars are much better than keeping such fruit in large receptacles, from which it is taken as needed, because molds grow freely on moist, sugary substances exposed to the air.

Molds and Molding.

Every housekeeper is familiar with molds which, under favorable conditions of warmth and moisture, grow upon almost any kind of organic material. This is seen in damp, warm weather, when molds form in a short time on all sorts of starchy foods, such as boiled potatoes, bread, mush, etc., as well as fresh, canned, and preserved fruits.

Molds develop from spores which are always float-

* Reprint of Farmers' Bulletin 366, issued by the Department of Agriculture.

ing about in the air. When a spore falls upon a substance containing moisture and suitable food it sends out a fine thread, which branches and works its way over and into the attacked substance. In a short time spores are produced and the work of reproduction goes on.

In the first stages molds are white or light gray and hardly noticeable; but when spores develop, the growth gradually becomes colored. In fact, the conditions of advanced growth might be likened to those of a flower garden. The threads—mycelium—might be likened to the roots of plants and the spores to the flower and seeds.

Mold spores are very light and are blown about by the wind. They are a little heavier than air, and drop on shelves, tables, and floor, and are easily set in motion again by the movement of a brush, duster, etc. If one of these spores drops on a jar of preserves or a tumbler of jelly, it will germinate if there be warmth and moisture enough in the storeroom. Molds do not ordinarily cause fermentation of canned foods, although they are the common cause of the decay of raw fruits. They are not as injurious to canned goods as are bacteria and yeasts. They do not penetrate deeply into preserves or jellies, or into liquids or semi-liquids, but if given time they will, at ordinary room temperature, work all through suitable solid substances which contain moisture. Nearly every housekeeper has seen this in the molding of a loaf of bread or cake.

In the work of canning, preserving, and jelly making it is important that the food shall be protected from the growth of molds as well as the growth of yeasts and bacteria.

To kill mold spores food must be exposed to a temperature of from 150 deg. F. to 212 deg. F. After this it should be kept in a cool, dry place and covered carefully that no floating spore can find lodgment on its surface.

Sterilization.

To sterilize a substance or thing is to destroy all life and sources of life in and about it. In following the brief outline of the structure and work of bacteria, yeasts, and molds, it has been seen that damage to foods comes through the growth of these organisms on or in the food; also that if such organisms are exposed to a temperature of 212 deg. F., life will be destroyed, but that spores and a few resisting bacteria are not destroyed at a temperature of 212 deg. F., unless exposed to it for two or more hours.

Bacteria and yeasts, which are intimately mixed with food, are not as easily destroyed as are those on smooth surfaces, such as the utensils and jars employed in the preparation of the food.

Since air and water, as well as the foods, contain bacteria and yeasts, and may contain mold spores, all utensils used in the process of preserving foods are liable to be contaminated with these organisms. For this reason all appliances, as well as the food, must be sterilized.

Stewpans, spoons, strainers, etc., may be put on the fire in cold or boiling water and boiled ten or fifteen minutes. Tumblers, bottles, glass jars, and covers should be put in cold water and heated gradually to the boiling point, and then boiled for ten or fifteen minutes. The jars must be taken one at a time from the boiling water at the moment they are to be filled with the boiling food. The work should be done in a well-swept and dusted room, and the clothing of the workers and the towels used should be clean. The food to be sterilized should be perfectly sound and clean.

As in this bulletin we have only to do with fruits, it will not be necessary to say anything more about long cooking at a high temperature.

In canning fruits it is well to remember that the product is more satisfactory if heated gradually to the boiling point and then cooked the given time.

(To be continued.)

NATURAL AND ARTIFICIAL ZEOLITES.

THEIR SIGNIFICANCE IN THE ECONOMY OF PLANTS.

BY PROF. O. N. WITT.

SINCE the days of Liebig it has been known that the food of plants, in so far as it is derived from the soil, consists of salts of potassium, calcium, magnesium, and iron. These are taken up by the plant in the form of nitrates, phosphates, sulphates and carbonates, the acid radicles of which also are essential to the plant. Now plants can take up these food materials only in dissolved form, for only so can these enter the fine root-hairs by diffusion. Hence we are faced with this problem: If the nutrient salts of plants are soluble in water, how is it that they are not dissolved and washed down by the rain, and accumulated in the underground water, far below the region occupied by the roots of plants? It is well known to the plant-physiologist that all fruitful soils retain such soluble salts with great tenacity, and but slowly yield them up to plants. An experiment is sometimes performed to illustrate this: A vessel having an outlet at the bottom is filled with coarse soil, and is sprinkled with a solution of saltpeter. The stream which flows off by the outlet at the bottom is pure water; the saltpeter, that important plant food, is retained by the soil. This is sometimes expressed by saying that the salts are retained in the soil by "adsorption." But the phenomenon is not explained by merely giving it a new name. It has been suggested that the clay in the soil, as a colloid, possesses the property of imbibing water, somewhat like a sponge, and that in this way salt solutions are retained in the soil. But in the author's opinion this would merely explain the tendency of most soils of remaining moist for a long time when once they have been wetted. Why soil completely wetted with water still fixes saltpeter and other salts when their solution is poured over it, does not seem to be explicable on the basis of the colloidal character of clay.

The true explanation is to be sought elsewhere; the phenomenon is due to the presence of zeolites in the soil. The zeolites are a comparatively small group of the class of minerals termed silicates. They are distinguished by the fact that they contain the elements of water as an essential constituent, and are readily decomposed by hydrochloric acid, with elimination of silica. Most zeolites are capable of forming well developed crystals, and contain, in addition to silica and water, also alumina and another metal oxide, such as soda, potash, lime, or iron oxide. The mineral pollux, which is found on the isle of Elba, is a zeolite containing the rare element caesium.

Zeolites can also be prepared artificially. They are obtained by fusing alumina or felspar with soda or potash and extracting the melt with water. The silicate present in the melt chemically binds a portion of the water added in the extraction, and is converted into a typical crystalline zeolite.

Now the zeolites have been found to possess a peculiar and most important property. The base which they contain aside from alumina, can be readily replaced by another base. Thus if a solution of a calcium salt is poured upon a zeolite containing sodium, it is converted into a calcium zeolite, and the sodium goes into solution. Similarly, if the product is treated with a solution of potash saltpeter, a potassium zeolite is obtained, and the calcium goes into solution. This kind of process can be repeated indefinitely. The "strength" or "weakness" of the base employed plays no part, the phenomenon is regulated entirely by the law of mass-action, and the metal present in excess in the solution, in every case displaces that present in smaller amount in the zeolite.

Now plants take advantage of this behavior of the zeolites. Consider a soil containing the usual metallic salts, fixed in part in the zeolites which are never quite absent from any soil. The roots of the plants growing in this soil come in contact with the grains of zeolite. Now roots are not only organs of assimilation, but also of excretion. They therefore bring to the zeolite solutions of those salts for which they have no further use, such as those of sodium, calcium, and magnesium. In most soils and waters these are present in greater abundance than is necessary for the plants. If for example the particle of zeolite in contact with a portion of the root, contains potassium, this latter becomes replaced by the other metal oxide eliminated by the plant, while the potassium is with avidity taken up into the root. After a time all the available potassium has been absorbed into the vegetation and the soil is impoverished. The wise farmer replenishes the supply by putting on a good dose of the right kind of fertilizer. For the time being there is a superfluity of the nutrient material; this would soon be swept away by rain, were it not for the action of the zeolites, which fix the bases in insoluble form. This cycle of changes is repeated time after time. During periods of scant food supply, the plants perforce take up other mineral bases, which they later exchange for potassium when the opportunity presents itself.

The knowledge of these phenomena gives us a better insight into the economy of plant life than it was possible to obtain hitherto. We understand the fact which has long been known, but hitherto has remained inexplicable, that plants at times take up metals for which they have little or no use in building up their substance. We realize also how it comes about that the plant does not overfeed in the presence of superfluity of food-material, and why it may continue to flourish for a long time if the supply of nutrient salts happens to be temporarily cut off. During winter, when plant life is almost at a standstill, when plants sleep, the zeolites, which never rest, collect the nutrient salts set free in the weathering process going on with special activity at that season, and store them up for use in the next summer. Thus the rejuvenation of the more or less exhausted autumn soil is provided for not only by the application of fertilizers—for which winter is justly recommended as the right season—but also by perfectly natural processes going on in the soil. The latter thus becomes enriched in preparation for the awakening of plant life in the spring; not however by a mysterious process of "adsorption," or by the swelling up of "colloids," but by the clearly intelligible and yet so marvelous chemical activity of the zeolites. And by the weathering of the mother-rock a continual regeneration is effected of these zeolites, whose overwhelming importance in the economy of nature was until recently not even dreamed of.

So remarkable and significant is this relation of the zeolites to plant life, that one is tempted to speak of a symbiosis of these lifeless minerals with the plant world.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Prometheus.

THE MEASUREMENT OF THE TEMPERATURE OF THE FIRE OF A LOCOMOTIVE IN MOTION.

THE power and the economy of every steam boiler, and especially of every locomotive boiler, depend upon the temperature of its fire. This temperature and its variations are not well known, because it has been almost impossible to measure the temperature while the locomotive is in motion, and the results obtained with a locomotive at rest do not correctly represent the temperatures attained in running. The reason of this is that the draft is largely dependent upon the speed of the locomotive, and also that the quantity of steam which escapes through the smokestack varies from zero to a very high percentage. In experiments recently made in Germany to measure the temperature while running, a Le Chatelier pyrometer was employed, which was connected with a galvanometer having a compensator, and so constructed that its sensitiveness was not impaired by the motion of a car. The difficulties met with chiefly concerned the arrangements for protecting the pyrometer from the direct action of the flame while exposing it to the hottest part of the fire. The temperatures obtained were very high, and in order to avoid the fusion of the wires of platinum-rhodium alloy, it was necessary to place the pyrometer high in the fire box and to inclose it in a tube of chrome steel which was itself surrounded by a cylinder of fire clay.

The temperature of the fire was found to be 13,350 deg. F. at a speed of 31 miles per hour, and 12,800 deg. F. at 19 miles per hour.

Ink Powder is made from coarsely pulverized constituents in the proportions in which they are used for ink. I. Powder for pure gall-nut ink: 32 parts gall nuts, 35 parts sulphate of iron (green vitriol), 1 part sulphate of copper (blue vitriol), 3 parts gum arabic. II. Powder for gall-nut-logwood ink: 24 parts of gall nuts, 5 parts of logwood extract, 10 parts sulphate of iron, and 5 to 8 parts of gum arabic. To each 1,000 parts of water, or better, 750 parts of water and 250 parts of vinegar, take 180 parts of ink powder. III. 15 parts each of carbolic acid and indigo-carmine, 210 parts each green vitriol and gum arabic, 480 parts of gall-nut powder. IV. 30 parts of tannin, 11.25 parts of green vitriol, 5 parts pulverized gum arabic, 3 parts sugar, 3 parts aniline blue, B. V. 500 parts extract of logwood are dissolved in a little water and a solution of 1 part bichromate of calcium added to it, evaporated to dryness and powdered. VI. 1 part nigrosine thoroughly mixed with ¼ part finely pulverized sugar suffices, with 80 parts of water, to produce a fine, free-flowing ink.

SCIENCE NOTES.

The "bleeding" of pine trees for their resin has generally been regarded as injurious to the timber, and in the specifications of many architects and railway companies, the "bled" timber is excluded. Investigations have been undertaken by the Forest Service of the United States Department of Agriculture in order to ascertain to what extent such timber is injured. The results of these tests indicate, however, that the "bled" timber is as strong as the "unbled" if of the same quality otherwise; that the weight and strength is not affected by the "bleeding"; and that the durability is the same of "bled" as "unbled" timber.—Machinery.

Calcium chloride is a grayish-white substance, which has the power of strongly attracting moisture from the atmosphere and of holding same. When used to dampen dust on coal mine roads, it contains nothing that can be injurious to the miner, roadways, haulage, ropes, etc. It does not give off any smell or gas. Comparing its hygroscopic property with that of salt, salt of itself has not the power of attracting moisture, but owes what little power it does possess to a small amount of impurity which it contains in the form of magnesium chloride, and cannot be for one moment compared with calcium chloride as a moisture-attracting substance.

A Gas Heating Research Committee, appointed by the Institution of Gas Engineers in connection with the University of Leeds, reports that: (a) The total radiation from an open gas fire is about 32 per cent. and this is unaffected by the amount of ventilation through the room; (b) no carbon monoxide escapes under ordinary conditions into the room and very little is ever found in the flue; (c) about 30 per cent of the heat generated in the stove passes directly into the flue—this figure varies with the volume of air passing through the stove flue; (d) there is no necessity for products of combustion to enter the room and cause discomfort; (e) reflectors may be usefully employed to produce a sensible increase of radiation into the region where it is most wanted.

In the course of a report to headquarters, Mr. Stuart K. Lupton, the United States Consul in the Catania district, states that while nothing has been done to reestablish the city of Messina, there can be no doubt that it will regain its old place, if for no other reason than because of its geographical position. It has the second best harbor of Italy, is situated on one of the great highways of commerce, and is the natural center for the products of eastern Sicily and Calabria. It has often been devastated by war and pestilence, and has more than once been shaken by violent earthquakes, but its natural advantages are too many to be disregarded, and it is probable there will be a city of Messina as long as there is any Sicily. The town will be rebuilt, but its reconstruction will be slow unless substantial aid is received from the government. After the great disaster of 1783 it was made a free port, and rapidly recovered from its losses on that account.

Insects play a most important part in timber destruction. The injury done is generally underestimated, as their depredations go on gradually, but forcibly, attracting little observation. When they bore into the timber they open up air chambers and channels which make it easy for rain water to seep in and thus keep the wood in a moist condition. Fungus spores floating through the air are enabled to germinate with greater rapidity and with increased effectiveness, and the decomposition of the pole consequently is materially hastened. Several years ago the Forest Service co operated with one of the large telephone companies in Georgia and Florida to experiment with various preservatives in protecting the butts of telephone poles from decay. These preservatives were simply painted upon the wood and, of course, did not sink in to any great depth. A recent examination made of this pole line showed that wherever the preservative had entered the wood no destruction due to insect attack had taken place, but where the wood was unprotected such injury was frequently quite serious.

The virtues of American gems are only beginning to be appreciated. Shortly after the discovery of America the Spanish introduced many American precious stones into Europe, a practice which languished and eventually died. Recently, however, the mining of American precious stones has taken on a new lease of life. Precious and ornamental stones of American origin, wonderful in perfection, are now to be found in many collections throughout the world. It is likely that diamonds will soon be mined in this country, for the stones have been found in Florida, Georgia, California, Wisconsin, North Carolina, Kentucky, and Arkansas. Some of these, perhaps, are emigrant diamonds. On the other hand, the region of Kentucky and Arkansas is as diamondiferous as that of Kimberley, South Africa. Our tourmalines, topazes, turquoises, rubies, sapphires, kunzites, spodumenes, and benoitites deserve to be more widely known. It is the duty of our miners and mine owners and of the jewelers who market the output of mines to aid the scientist and the mineralogist in more widely introducing our native gems as well as our unique ornamental stones into foreign countries. Perhaps one way of accomplishing this result would be the formation of some traveling collections, which would serve the purpose of illustrating the wonderful variety in colors of North American precious stones, ornamental stones, and stones of adornment.

ENGINEERING NOTES.

The Calcutta Railways states that "the extended use of the monorail system of transport for passengers and goods depends very much upon a satisfactory pattern of carriage, and Mr. Brennan is working hard to reach success in this direction. Experiments are now being made in short lengths on roads near Kamarhati and Dharampur—Kalka-Simla road—with a view to testing the value of monorail for military purposes on hill roads. A report will be furnished when the trials have come to an end."

The New York Railway Club has appointed a special committee to study the subject of steam railway electrification, which will render a report of its work for consideration at the annual electrical meeting of the club next March. The committee is to collate and tabulate such general data as may be of interest to railway men, and make such suggestions as may appear pertinent to them with reference to the direction in which it would be desirable to have further investigation and information. The Maintenance of Way Association and the American Railway Association are considering the subject of electrification along substantially the same lines.

The methods adopted in Canada in grinding mica are referred to briefly in Cirkel's "Mica, Its Occurrence, Exploitation and Uses." This author remarks that the processes are usually kept secret, though in some cases they appear to be very simple, old-fashioned burrstones being used for the purpose of grinding the mineral. The scrap mica, free from rust or gangue, is bought at from $8 to $10 a ton. The process adopted by one company in Ontario is described as follows: "The mica is first roughly screened, and then cleaned before entering the grinder, which is a sheet iron cylinder, 9 feet long by 3 inches in diameter, punched in rows, and set at an incline of 1½ inches in its length. As the machine slowly revolves, loose pieces of steel inclosed in the cylinder pulverize the mica until fine enough to drop through the holes, which are 3/16 inch in diameter. It is then sized and graded in trommels from flakes down to the finest powder, the finest screens being of silk. The plant is operated by water-power on the Gananoque River."

A number of coal briquette press installations have been made in the United States during the last few years, but only a small quantity of briquettes have been manufactured, and with some exceptions the plants were short lived. The enormous increase in the coal production in the country, together with the low cost, and the accessibility of thick veins, has scarcely warranted coal operators devoting much time and money to the subject, and where plants have been erected, it is believed that the conditions were not sufficiently investigated. A number of machines were manufactured or imported and sold to coal companies on the representation of results based on the experience of similar plants in foreign countries. It usually turned out, however, that in some important features the results differed largely from the representations made, and in consequence of many failures, briquetting has been considered an impracticable proposition.

In a paper recently communicated to the London Section of the Society of Chemical Industry, Mr. G. Nevill Huntly discussed the cause of pitting which has occurred in a standby boiler at the generating station of the London Electric Supply Corporation. Numerous blisters were found on the interior surface of the boiler, most of them being near the water level. It was found that each blister contained liquid with a fine black powder held in suspension. This liquid was found to be acid ferrous sulphate. The water in the boiler contained 0.635 pound of caustic soda per 1,000 gallons, and was slightly alkaline. It is well known, said Mr. Huntly, that sulphur in steel is present as manganese sulphide, ferrous sulphide only appearing when the quantity of manganese is insufficient. He suggested that the acid liquid was formed by the action of the oxygn dissolved in the water on the manganese sulphide. It has been generally believed that small quantities of manganese sulphide in steel are almost harmless, but if Mr. Huntly's explanation of the cause of corrosion is correct greater attention must be given to the influence of this compound. For the past two years an alkaline arsenite has been added to the boiler water instead of caustic soda, and since this change was made no blisters have been observed on the boiler plates. Mr. Huntly suggests that this is due to the oxygen dissolved in the water being employed in oxidizing the arsenite instead of the manganese sulphide.

TRADE NOTES AND FORMULÆ.

Filler.—This surfacer, which originated in England, is used in carriage factories. It is gray to brown and is applied with a spatula. It is prepared by rubbing down, in a paint mill, 16 parts of white lead, 15 parts dark-brown umber, 20 parts chalk, 30 parts heavy spar, 12 parts siccative, 5 parts oil of turpentine, and 20 parts linseed oil varnish.

Infusorial Earth Putty.—10 parts of washed infusorial earth (kieselguhr), 8 parts of litharge, 5 parts of slaked lime, 6 parts of boiled linseed oil, 1 part red lead, 1 part zinc white. This putty, in a few months, becomes as hard as fine-grained sandstone and can be employed advantageously as a filling cement for stone.

Veneering with Waterproof Glue.—Ordinary glue is steeped in water until it swells without breaking down from its original form. Thus softened, it is transferred, without the addition of water, to an iron pot, linseed oil added, according to the quantity of glue, and the mixture boiled over a slow fire until a jelly-like mass results. Such glue will join various materials in the most permanent manner, it holds remarkably well, dries quickly, and withstands moisture.

Albumen Preparation from Blood (for finishing, food substance, coatings, etc.).—Blood coagulum is treated with alcohol or acetone, with addition of 0.5 per cent of an acid, an alkali or an alkaline carbonate and extracted so long until the greater portion of the hæmatin and coloring constituents are extracted. Complete recoloration is effected when the resultant product is distributed in water and where the addition of a suitable bleaching material, like chlorine, permanganate of potash or peroxide of hydrogen is resorted to for bleaching.

Varnish from Hard-Rubber Waste.—Hard-rubber waste can be made into a good varnish that dries quickly and can be of a beautiful yellow or non-transparent brown, holding especially well on metal. The varnish is made as follows: The hard-rubber waste is placed in an iron pot, that closes well with a lid, and the pot placed on a hot coal fire. After about five minutes take the pot from the fire and see if the waste is melted. If the melting is so far advanced that it can readily be poured out and there are no unmelted pieces present, which can easily be ascertained with the help of a thick wire, the contents of the pot are poured on to a sheet of metal, previously greased, so that after cooling the mass may be easily detached. The cooled mass is broken up and benzol or rectified oil of turpentine poured over it. When completely dissolved, which may be accelerated by frequent shaking, pour off the fluid carefully from the impurities always found in hard rubber, which settle to the bottom of the vessel.

Carbolineum.—I. 95 parts of raw, light coal tar oil are heated with 5 parts of asphalt (from coal tar) and thoroughly mixed. The coal tar oil may also be replaced with wood tar oil. II. 1 part heavy coal tar oil, 2 parts light, raw, wood tar oil, ¼ part heavy rosin oil. The coal tar and wood tar oils must be freed from carbolic acid and creosote, which is to be effected by washing with caustic lye and distillation. III. Light wood tar is mixed with some crude carbolic acid. IV. The finest grade: In an iron kettle 100 parts of anthracene oil and 10 parts of dark American rosin are perfectly and uniformly melted at a moderate heat. Then add 1 to 2 parts of rubber or caoutchouc solution—according to the covering capacity the carbolineum is expected to possess—and continue boiling gently until all is dissolved. When this is effected, add 5 parts more of crude, concentrated carbolic acid, the 100 per cent kind, stir well and transfer to storage casks for clarification. The coating produced by this carbolineum is deep brown, exceedingly durable and preserves wood of all kinds thoroughly that is exposed to moisture or wet constantly, mine timbers, for instance.

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